Sauget Area 2 Sites Group

January 30, 2004

Nabil Fayoumi
Remedial Project Manager
USEPA
77 W. Jackson Blvd. (SR-6J)
Chicago, IL 60604-3590

RE: Sauget Area 2 Sites

Dear Nabil:

Attached please find two (2) paper copies and one electronic disc copy of the Remedial Investigation / Feasibility Study as required by the Administrative Order by Consent. Paper and/or disc copies are also being submitted directly to the other review agencies and CH2M Hill, as indicated in the cc list below.

If you have any questions please contact me at (970) 225-6400.

Sincerely,

Gary D. Uphoff for
Interim Project Coordinator

cc: Sandra Bron - Illinois EPA (2 Paper Copies, 1 Disc)
Mike Coffey - U.S. Fish & Wildlife (1Disc)
Steve Davis - Illinois Department of Natural Resources (1Disc)
Peter Barrett - CH2M Hill (2 Paper Copies, 1 Disc)

SAUGET AREA 2,
SAUGET, ILLINOIS

REMEDIAL INVESTIGATION/ FEASIBILITY STUDY REPORT VOLUME 1 - Text

Prepared for

Sauget Area 2 Sites Group
c/o Gary Uphoff
Environmental Management Services
5934 Nicklaus Drive
Fort Collins, CO 80528

January 30, 2004

URS

URS Corporation
1001 Highland Plaza Drive West, Suite 300
St. Louis, MO 63110
(314) 429-0100
Project #21560888.07001

The document contains references to the completion of a barrier wall at Site R during the first quarter of 2004. On December 17, 2003, Solutia and its subsidiaries filed for bankruptcy protection. The completion date and status of this project is unknown to the Sauget Area 2 Group because Solutia managed this construction project pursuant to the terms of a previously issued Unilateral Administrative Order (UAO).

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List of Acronyms and Abbreviations

ABRTF	American Bottoms Regional Wastewater Treatment Facility
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirements
BERA	Baseline Ecological Risk Assessment
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CGM	Combustible gas meter
COC	Constituent(s) of Concern
DHU	Deep Hydrogeologic Unit
DO	dissolved oxygen
DOT	Department of Transportation
ERRS	Emergency and Rapid Response Services
FSP	Field Sampling Plan
GC	gas chromatograph
GC/MS	gas chromatography coupled with mass spectrometry
GPS	global positioning system
HASP	Health and Safety Plan
HHRA	Human Health Risk Assessment
HI	Hazard Index
IDW	investigative-derived waste
IEPA	Illinois Environmental Protection Agency
LCS	Laboratory Control Sample
MGD	Millions Gallons per Day
MHU	Medium Hydrogeologic Unit
MLE	Most Likely Exposure
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MSL	Mean Sea Level
NAPL	Non-Aqueous Phase Liquid
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity units
ORP	oxygen reduction potential
OSHA	Occupational Safety and Health Administration
OU	Operable Unit
PCB	polychlorinated biphenyl
PID	photoionization detector
PM2.5	particulate matter 2.5μm
POTW	Publicly Owned Treatment Works
PPE	Personal protective equipment
ppb	parts per billion
ppm	parts per million
PRP	Potentially Responsible Party
PUF	polyurethane foam

List of Acronyms and Abbreviations

PVC	polyvinyl chloride
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidance for Superfund
RAM	Real-time aerosol monitor
RAO	Remedial Action Objective
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SA2	Sauget Area 2
SA2SG	Sauget Area 2 Sites Group
SDG	sample delivery group
SHU	Shallow Hydrogeologic Unit
SSP	Support Sampling Plan
SVE	soil vapor extraction
SVOC	semi-volatile organic compounds
TCLP	toxicity characteristic leaching procedure
TOC	Top of Casing
USACE	U.S. Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

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On November 20, 2000, the Sauget Area 2 Sites Group (SA2SG) Potentially Responsible Parties (PRPs) signed an Administrative Order on Consent (AOC), Docket Number V-W-01-C-622, to perform a Remedial Investigation/Feasibility Study (RI/FS) at five waste disposal sites known as Sauget Area 2 (SA2) Sites O, P, Q, R and S. U.S. Environmental Protection Agency (USEPA) Region V signed the AOC on November 24, 2000. The SA2 Sites are located in the City of East St. Louis and the Villages of Sauget and Cahokia in St. Clair County, Illinois. The SA2 study area is east of the Mississippi River and south of the MacArthur Bridge railroad tracks. The study area is west of Route 3 (Mississippi Avenue) and north of Cargill Road. Figure ES-1 shows the five sites.

SITE BACKGROUND

SA2 consists of five former disposal sites, Sites O, P, Q, R, and S adjacent to or in close proximity, to the Mississippi River. Disposal activities at the five sites generally consisted of:

Site	Former Use	Municipality
Site O	Sewage Sludge Dewatering	Village of Sauget
Site P	Municipal and Industrial Waste Disposal	City of East St. Louis Village of Sauget
Site Q	Municipal and Industrial Waste Disposal	Village of Sauget Village of Cahokia
Site R	Industrial Waste Disposal	Village of Sauget
Site S	Chemical Reprocessing Waste Disposal	Village of Sauget

These sites are located within the floodplain of the Mississippi River, with topographic elevations ranging from 400 to 410 feet above Mean Sea Level (MSL).

The surficial material at the SA2 Sites consists mainly of fill, usually a gravel or vegetative cover overlying the waste material. The unconsolidated deposits underlying the fill material consists of the poorly sorted, fine-grained materials of the Cahokia Alluvium. The Henry Formation, which consists of medium to coarse-grained glacial outwash sands, underlies the Cahokia Alluvium. These unconsolidated deposits are approximately 120- to 140-feet thick and contain three groundwater-bearing zones; the shallow hydrologic unit (SHU), the medium hydrologic unit (MHU), and the deep groundwater hydrologic unit (DHU). Underlying the unconsolidated deposits is Pennsylvanian and Mississippian aged limestone, which also contains groundwater.

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Groundwater usage in the Villages of Sauget and Cahokia is controlled by village ordinance, and groundwater is not used for drinking water in these areas. The current surrounding land use consists mainly of heavy industry, warehouse space, trucking, and other commercial businesses. The nearest residential area is approximately 3,000 feet east of the study area in the City of East St. Louis and the Village of Sauget. The previous and current facilities upgradient of SA2 include:

- Astaris – Phosphorous Pentasulfide Manufacturing
- Big River Zinc – Zinc Refining
- Cerro Copper – Copper Tube Manufacturing
- Ethyl Petroleum Additives, Inc. – Petroleum Additive Manufacturing
- Flexys – Rubber Chemicals Manufacturing
- Oxychem – Swimming Pool Chlorine Manufacturing
- Solutia – Monchlorobenzene Manufacturing
- Sterling Steel Castings – Foundry
- American Bottoms Regional Treatment Facility – Wastewater Treatment Plant
- Darling Fertilizer – Manufactured Chemical Fertilizers
- Midwest Rubber – Reclaimed Rubber principally from Discarded Tires
- Phillips Petroleum – Petroleum and Propane Storage and Transfer Facility
- Resource Recovery Group – Railroad Repair Yard and Solvent Reclamation
- Onyx Environmental – Hazardous Waste Incinerator.

Previous removal actions have been performed at Sites O, Q, and R and these actions include:

- Site O: 1980 – The Village of Sauget closed the four lagoons by stabilizing the sludge with lime and covering with approximately 2 feet of clean, low-permeability soil.
- Site Q: 1999 – USEPA excavated and disposed of 17,032 tons of waste from 8 excavation areas.
- Site R: 1979 – Monsanto installed a clay cover, ranging in thickness from 2 to 8 feet.

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- Site R: 1985 – Monsanto installed 2,250-foot long rock revetment along the east bank of the Mississippi River adjacent to Site R.
- Site R: 2003 – Solutia began construction of a 3,300-foot long barrier wall and groundwater extraction system along the west side of Site R.

Sauget Area 2 Interim Groundwater Remedy

USEPA issued a Unilateral Administrative Order (V-W-'02-C-716) for Remedial Design and Interim Remedial Action on October 3, 2002 for a Remedial Design/Remedial Action for the SA2 Groundwater Operable Unit (OU-2), which encompassed the groundwater contamination releasing to the Mississippi River adjacent to Site R and the resulting impact area in the river. On September 30, 2002, USEPA selected an interim groundwater remedy for this OU consisting of a 3,500-feet long, 140-feet deep, "U"-shaped, fully-penetrating barrier wall installed between the downgradient boundary of SA2 Site R and the Mississippi River and three-partially penetrating groundwater recovery wells inside the barrier. Implementation of this remedy will abate the release of impacted groundwater to the Mississippi River and control groundwater moving into the barrier wall. In response to this Order, which became effective on November 15, 2002, Solutia submitted a Remedial Design/Remedial Action Work Plan for the Sauget Area 2 Groundwater Migration Control System on December 29, 2002, a Pre-Final Design on January 21, 2003 and a Final Design on July 3, 2003. USEPA issued "Conditional Approval of the Groundwater Extraction System Design" on May 15, 2003. Construction of the extraction wells, discharge piping and control system was completed and the groundwater extraction system was started on July 15, 2003. Discharge rates were initially limited by the American Bottoms Regional Wastewater Treatment Facility (ABRTF) to ensure successful acclimatization of the biological wastewater treatment system, however, full discharge to the POTW started on October 22, 2003. USEPA approved the Final Design for the Sauget Area 2 Interim Groundwater Remedy (SA2IGR) on October 16, 2003. In anticipation of design approval, equipment for installation of the barrier wall was mobilized to Site R on August 18, 2003, pre-trenching for the slurry wall began on August 29, 2003 and slurry trench excavation began on September 4, 2003. As of December 5, 2003, approximately 1,100 feet of slurry trench was excavated to bedrock, which was encountered at a depth of approximately 135 feet. Current plans call for completing installation of the barrier wall in the first quarter of 2004.

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REMEDIAL INVESTIGATION

The RI activities were conducted between June and October 2002 (except for the Site Q screening survey in November 2001 and quarterly sampling events in January, April, and June 2003) in accordance with the RI/FS Support Sampling Plan (SSP) (SA2SG, 2002), dated April 15, 2002 and associated addenda. The RI sampling activities were developed to characterize affected media in SA2 and to develop data necessary to support a risk-based remedy selection. The primary activities completed as part of the SSP included:

- Delineation of disposal area boundaries
- Characterization of the waste
- Characterization of aquifer parameters
- Evaluation of the soil and groundwater
- Evaluation of the sediment, surface water, and air
- Evaluation of stormwater
- Evaluation of seeps
- Performance of pilot treatability studies
- Completion of Human Health and Ecological Risk Assessments
- Preparation of a Feasibility Study.

Each sampling location is shown in Figure ES-1.

Following the completion of the RI activities, the SA2SG submitted several interim reports to USEPA and Illinois Environmental Protection Agency (IEPA). These submittals were intended to provide an on-going transmittal of data and pertinent information. These submittals are:

- Support Sampling Data Report - April 1, 2003 - This report included all the data on a constituent-by-constituent basis (URS, 2003a)
- Data Validation Report - May 1, 2003 - This report included a summary of the data validation process and the resulting validated data including the data for samples collected in 2002 (URS, 2003b)

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- The Field Sampling Report - June 25, 2003 - This report included a summary of field and sample collection procedures (URS, 2003c) (FSP).
- Field Sampling Report of Aquatic Sampling Activities – June 5, 2003 – This report included a summary of field and sample collection procedures for aquatic samples use in the BERA (AMEC, 2003a).
- Floodplain Area Field Sampling Report – June 10, 2003 – This report included a summary of field and sample collection procedures for floodplain samples used in the BERA (AMEC, 2003b).
- Human Health Risk Assessment - August 31, 2003 - This report included an evaluation of human health risks based on the analytical data (ENSR, 2003) (HHRA).
- Baseline Ecological Risk Assessment - August 2003 -This report included an evaluation of ecological risks based on the analytical data (AMEC, 2003c) (BERA).

Delineation of Disposal Area Boundaries

The initial phase of the RI (delineation of disposal area boundaries) began prior to initiation of field activities with an aerial photograph analysis. A total of 19 aerial photographs ranging from 1955 to 2000 were analyzed to determine the potential disposal area boundaries. The waste disposal areas identified through the aerial photo analysis were investigated further through the use of magnetometer surveys, soil gas surveys, and test trenches.

Magnetometer Surveys

Magnetometer surveys were conducted at four of the five sites (P, Q, R, and S) to identify magnetic anomalies in the subsurface. No magnetometer survey was conducted at Site O since site closure records indicated that there were no drums present. Magnetometer measurements were collected at the center points of a 50 by 50-foot grid superimposed on each disposal area. During the performance of the survey, data was collected, which resulted in contour maps depicting the distribution of the magnetic field strength over the site, and areas with anomalous readings were noted.

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Soil Gas Survey

A soil gas survey consisting of a shallow soil probe (5 feet) and on-site analysis of collected vapors for volatile organic compounds (VOCs) using a Gas Chromatograph (GC) was performed at each of the five sites. Soil gas samples were collected at the center points of a 200 by 200-foot grid superimposed on each disposal area. In addition, if elevated VOC concentrations were detected at the boundary of a site, additional soil gas samples were collected along a transect, perpendicular to the site boundary, at 100-foot intervals until the VOC concentrations fell below the laboratory reporting limit. A total of 354 soil gas borings were advanced to determine the extent of potentially impacted material.

Test Trenches

Two types of test trenches were excavated during the investigation (boundary trenches and anomaly trenches). A total of 24 boundary trenches were advanced along the disposal area boundaries to identify the edge of waste. Each trench began outside an assumed disposal area boundary and moved in towards the boundary until waste was encountered. If waste was initially encountered, the trenching activities proceeded out and away from the boundary until native soil was encountered. In some instances, boundary trenches were unable to continue past obstructions, such as roadways and utility corridors. A total of 11 anomaly trenches were excavated to investigate the presence of magnetometer anomalies. Each anomaly trench was excavated at a predetermined location within a waste disposal area, typically corresponding to a magnetic anomaly. These trenches were continued until buried drums were encountered or for a maximum of 40-feet. During the course of trenching activities (both boundary and anomaly trenches) no intact drums were encountered.

Waste Characterization

A total of 25 waste borings were advanced using both direct push and sonic drilling technologies and seven leachate-monitoring wells were installed. These borings and wells were designed to characterize the waste and leachate present at each site. Waste samples that were collected during drilling activities at a particular site were combined, and a composite waste sample for that site was analyzed for semi-volatile organic compounds (SVOCs), pesticides, herbicides, polychlorinated biphenyl (PCBs), and metals. A separate, discrete sample was collected at the sample interval with the highest photoionization detector (PID) reading and analyzed for VOCs

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and dioxins. In addition, a second sample (both discrete and composite) was collected at each site and analyzed following Toxicity Characteristic Leaching Procedure (TCLP) extraction. The TCLP extraction was performed to obtain an aqueous solution, which was analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, and metals. The results of these samples in which TCLP extraction was performed will be referred to as "TCLP extract" throughout this document. Standard TCLP analyses were performed separately and used later to determine if the subsurface materials could be classified as a characteristically hazardous waste. Each leachate well was sampled for four quarters (provided there was enough material available in the well to sample). During this investigation, samples from the leachate well at Site R and one of the leachate wells at Site Q were collected in each of the four quarters. The leachate well at Site O contained sufficient material to be sampled during the first event only, and the remaining wells did not contain sufficient material to be sampled during any of the four quarterly sampling events.

Hydrogeology

Alluvial Aquifer Borings

Groundwater samples were collected at 10-foot increments from the top of the water table to the bottom of the aquifer using direct push technology at locations representing upgradient and downgradient conditions for each of the five sites. Samples were collected at a total of 22 locations, including four upgradient locations and 18 downgradient locations. Every sample collected was analyzed for VOCs and SVOCs. In addition, at least one sample was collected in each hydrogeologic unit for the full suite of parameters, which included VOCs, SVOCs, pesticides, herbicides, PCBs, and metals. Dioxins were also collected as part of the full suite of analysis in a previously selected set of profile locations.

Bedrock Monitoring Wells and Piezometers

A total of 6 bedrock-monitoring wells and 27 piezometers were installed using sonic technology. Each bedrock monitoring well was advanced approximately 25-feet into competent bedrock and sampled during each of the four quarterly groundwater sampling events for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals. The piezometers were installed in the alluvial aquifer at nine locations with three piezometers at each location. Each location "cluster" contained one piezometer set in each of the three hydrogeologic units. All bedrock wells and piezometers were gauged during each of the four quarterly sampling events and groundwater contour maps produced.

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In addition to gauging and sampling activities, slug tests were completed on each piezometer and bedrock groundwater monitoring well. The results were reduced using the AQTESOLV® computer program to produce hydraulic conductivity values.

Soil Sampling

A total of 38 surface soil samples and 30 subsurface soil samples were collected at both on-site and off-site locations. Surface soil samples were collected between the ground surface and 0.5 feet below ground surface (bgs) and the subsurface samples were collected from 0.5 to 6 feet bgs. Each sample was analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals.

River Sediment

A total of 43 surface water samples and 41 sediment samples were collected from six sampling plots in the Mississippi River. Each sampling plot contained seven sample locations, except for plot 5 since some samples were unable to be collected due to rock at the bottom of the river. The seven sample locations within a sampling plot were evenly distributed along three transects at distances of 50 feet, 150 feet and 300 feet from the shore. The first two transects contained three sample locations each with locations positioned upstream, mid-stream, and downstream. The third transect (300 feet from the shore) contained only one sample location at the mid-stream position.

All surface water samples were collected from approximately one-foot above the sediment-surface water interface, after recording the water quality parameters. One end of a pre-cleaned FEP-lined polyethylene tube (1/4-inch I.D.) was attached to a Van Veen sampler and the Van-Veen sampler was lowered gently until it reached the bottom. The other end of the tube was inserted into the inlet end of the silicone tubing attached to the pump head of the Solinst Peristaltic Pump (Model 410). The tubes were purged with about 8-10 liters of river water, which was collected separately in a bucket, and released back to the river after all waste sampling was completed at a sampling point. After purging, water samples were collected in pre-labeled sample containers, directly from the outlet end of the silicone tubing. Samples were collected for VOC, SVOC, pesticides, herbicides, PCBs, dioxins, metals and bio-assay experiments, in that order.

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Sediment samples were collected using a Van-Veen sampler. This grab sampler takes a 13-inch square surface sample from the top six-inches of the sediment layer, and has a capacity of 20 L. The Van-Veen sampler was prepared for sediment sampling by bringing the sampler to an open position and resetting the release mechanism. It was then lowered until it hit the sediment layer, which released the jaws, aiding the sample collection. A sample was initially collected for VOCs and then, large gravels, sticks, and other foreign objects were removed and discarded. Samples were then collected for SVOCs, pesticides, herbicides, PCBs, dioxins, metals and bio-assay and bioaccumulation tests.

Additional Media

Several additional sampling activities were also conducted as part of the RI. These included:

- Air Sampling – Ambient air samples were collected at 16 locations and analyzed for VOCs, SVOCs, pesticides, dioxins, and metals.
- Stormwater Sampling – Stormwater run-off samples were collected at three locations during two rainfall events and analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals.
- Seep Sampling – Seeps samples were collected from three locations and analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals.

Each sample that was collected during the RI activities was sent to Severn Trent Laboratories for analysis and the analytical results were validated by URS. Ninety percent of the laboratory analytical results were validated using the Level III data validation protocol and 10% were validated using the Level IV protocol. The data validation process resulted in greater than 99% of the data being considered acceptable data, which meets the objectives set forth in the Quality Assurance Project Plan (QAPP) (URS, 2002c).

SOURCE NATURE AND EXTENT

The major findings of this evaluation of the nature and extent of source areas and the nature and extent of migration from the source areas are:

Source Areas

- Surface soil concentrations were generally lower than subsoil concentrations
- Subsurface soil concentrations were generally lower than waste concentrations

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- Waste concentrations were generally the highest concentrations detected in the source areas
- TCLP-extract concentrations were generally lower than leachate concentrations
- The waste within Sites O, P, Q and S do not appear to currently be significant on-going sources of impact to the underlying aquifer.

Groundwater

- Leachate and TCLP-extract concentrations were generally higher than shallow groundwater concentrations
- Groundwater concentrations generally increased with depth
- Upgradient groundwater concentrations were generally higher than downgradient concentrations at Sites O and S
- Downgradient groundwater concentrations were generally higher than upgradient concentrations at Sites P, Q North and R
- Three groundwater plumes exist on-site:
  - Plume 1 – Located in the central part of the site along the east side and underlies Sites O, P, and S. This plume originates east of Illinois Route 3 and is coming onto the SA2 Site (from upgradient sources).
  - Plume 2 – Located immediately beneath and adjacent to Site R, appears to originate at Site R and then combine with Plume 1 and move directly toward the Mississippi River.
  - Plume 3 – Located in Site Q South near the border with Site Q Central. The origin of this plume is unknown but appears to be from an upgradient source(s). This plume does not appear to reach the Mississippi River.

  These three plumes are shown in Figures ES-2 and ES-3.
- At least one groundwater sample at each location contained at least one constituent concentration that exceeded the Illinois Environmental Protection Agency (IEPA) Class I Groundwater Standards, Figure ES-4.

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Sediments and Surface Water

- Sediment and surface water concentrations were generally higher downgradient of Sites O, Q North, R and S than downgradient of Sites P, Q Central and Q South.
- The only sediment and surface water sampling location that showed impact was adjacent to the southwest corner of Site R.

GROUNDWATER MODELING

Groundwater Services, Inc. (GSI) of Houston, Texas developed a groundwater model for the Sauget Area 2 FFS as an analysis tool for the Site R Interim Remedy. The same modeling technology was again implemented as an analysis tool for the RI/FS performed for the entire SA2 Site.

The objective of the FFS study was to determine pumping rates for two alternative designs for a groundwater barrier located between SA2 Site R and Mississippi River: i) Groundwater Alternative B – Physical Barrier (a "U"-shaped physical barrier together with groundwater pumping); and ii) Groundwater Alternative C – Hydraulic Barrier (groundwater pumping alone to form a hydraulic barrier). A numerical groundwater flow model, MODFLOW, was used to meet these objectives.

Results

The modeling analysis indicated that the flow rate of affected groundwater from the water-bearing units underlying Site R to the Mississippi River during average river level conditions is 535 gpm. The sensitivity analysis indicates that this flow rate decreases when the river stage is high and increases when the river stage is low. When the monthly average high river stage and monthly average low river stage are used in the model (with all other parameters unchanged), the modeling indicates that the flow rate of affected groundwater from Site R to the river ranges from 303 gpm to 724 gpm. Sensitivity analysis also indicates that MODFLOW results are most sensitive to changes in river stage and insensitive or less sensitive to other changes.

The design basis flow rate for Alternative B – Physical Barrier is for the pumping system associated with this alternative to pump at a rate equivalent to the flow rate of groundwater flowing into the "U"-shaped physical barrier. Analytical capture zone relationships show that

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the Alternative C – Hydraulic Barrier system needs to pump at twice the flow rate of natural groundwater flow flowing past the desired capture width of the hydraulic barrier.

Based on these design bases, the resulting design flow rates are:

River Level	Design Pumping Rate for Three Well System (gpm)	
	Alternative B – Physical Barrier	Alternative C – Hydraulic Barrier
Higher River Stage (monthly average high river stage of 401 ft amsl)	303	606
Average River Stage (monthly average river stage of 391 amsl)	535	1070
Lower River Stage (monthly average low river stage of 383 ft amsl)	724	1448

A qualitative analysis indicates that a three-well pumping system will serve as an effective groundwater recovery system for Alternative B and Alternative C.

The MODFLOW groundwater model developed for the Sauget Area 2 Focused Feasibility Study (Volume 2, Interim Groundwater Remedy Design Basis, Solutia Inc., March 2002) was refined and calibrated for the entire SA2 Site. The existing groundwater flow model was originally developed as an analysis tool for the Site R interim remedy. Therefore, the original model calibration effort was focused in the vicinity of Site R to optimize simulation of conditions near Site R. The objective of this task was to verify that the current model calibration was appropriate to reasonably simulate conditions across all of SA2 Site.

Flow calibration against water levels measured on June 9, 2003 was performed by adjusting the Mississippi River level to the actual level on June 9, 2003 and comparing the model-predicted values to the actual measured values for nine piezometers, each screened in the shallow, middle, and deep hydrogeologic units. Overall, the MODFLOW groundwater flow model was considered to yield a reasonable simulation of the aquifer system and all parameters used for the initial Interim Groundwater Remedy Design Basis Report were retained.

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HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

A baseline Human Health Risk Assessment (HHRA) and a Baseline Ecological Risk Assessment (BERA) were conducted by ENSR International, and AMEC Earth and Environmental, Inc., respectively.

Conclusions of the HHRA

Conclusions of the HHRA indicated the following:

Site	Receptors	Constituent of Concern	
Site O	Outdoor Industrial Worker Construction/Utility Worker	Xylenes Chlorobenzene	Benzene PCBs
Site O North	Outdoor Industrial Worker Construction/Utility Worker Trespassing Teenager	PCBs 2,3,7,8-TCDD TEQ	Xylenes
Site Q North	Construction/Utility Worker	2,4,6-Trichlorophenol 2,4-Dichlorophenol	
Site Q Ponds	Recreational Fisher	PCBs Dieldrin 2,3,7,8-TCDD TEQ	Benzo(a)pyrene Arsenic
Site R	Outdoor Industrial Worker Construction/Utility Worker	Trichloroethylene PCBs	1,2-Dichloroethane Mercury
Site S	Outdoor Industrial Worker Construction/Utility Worker Trespassing Teenager	PCBs	

A summary of the full list of Constituents of Concern (COC) with the respective site and receptors is provided in Table ES-1 (provided in Section 8.1). These areas of potential risks are shown in Figure ES-5.

Conclusions of the BERA

The BERA concluded that no adverse ecological impacts were associated with sediments within the Mississippi River. Limited surface water impacts based on toxicity testing were identified with p-chloroaniline and 2,4-D identified as the principal COC in surface water. With the implementation of the Sauget Area 2 Interim Groundwater Remedy (SA2IGR) at Site R, no additional remedial actions are considered necessary to protect the aquatic ecosystem in the Mississippi River.

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The BERA also identified the potential for adverse ecological impacts associated with the presence of COPECs in surface soil found in Sites O and S. For Site O, the most significant COPECs included dieldrin, lindane, PCBs, dioxins/furans, aluminum, and mercury. For Site S, the most significant COPECs included pentachlorophenol, beta-BHC, endrin, and lindane, and PCBs. These areas will be evaluated further in the Feasibility Study for the identification of potential remedial actions. Limited ecological risks were identified with surface water and sediments in Site Q (Ponds), however, a further determination of ecological risk will be made upon the evaluation of surface water and sediment quality data collected in June 2003. These areas of potential risk, identified in the BERA, are shown in Figure ES-6.

FEASIBILITY STUDY

Identification of Remedial Action Objectives Sauget Area 2

Remedial action objectives (RAOs) form the basis for identifying remedial technologies and developing remedial alternatives for further evaluation. RAOs are site-specific, qualitative objectives based on the nature and distribution of contamination, the resources currently or potentially threatened, and the potential for human and environmental exposure. RAOs for SA2 were formulated based on environmental concerns defined in the HHRA and the BERA. It should be noted that the use of groundwater in the vicinity of the SA2 Site as a drinking water source is prohibited. As a result, the HHRA evaluated potential incidental exposures to groundwater (i.e., non-drinking water scenarios) including contact by a construction/utility worker performing excavation in the area or volatilization through the soil column resulting in exposure to chemicals of concern in indoor or outdoor air.

Site P, Q Central, and Q South

The HHRA indicated that all potential risks, both carcinogenic and non-carcinogenic, calculated for both the Reasonable Maximum Exposure (RME) and Most Likely Exposure (MLE) receptor scenarios are within or below the USEPA's target risk range of 10^{-6} to 10^{-4} and below the Hazard Index (HI) of 1. In addition, no ecological risks were identified for these sites. As a result, no site specific RAOs have been developed for Site P, Q Central and Q South.

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Summary of Remedial Action Objectives

Aside from the individual chemicals of concern, the RAOs for the various sites at SA2 Sites considered in the FS are similar. As a result, the RAOs for the SA2 Sites O and O North, Q North, Q Ponds, R and S can be summarized as follows:

- Minimize potential risks to human receptors resulting from exposure to the chemicals of concern found in site surface and subsurface soils at Site O, Site O North, Site R, and Site S.
- Minimize potential risks to human receptors resulting from exposure to the chemicals of concern through the consumption of fish fillets obtained from Site Q Ponds.
- Minimize potential risks to ecological receptors resulting from exposure to the chemicals of concern found in site surface soils at Site O and Site S.
- Minimize potential risks to human receptors resulting from exposure to the chemicals of concern found in leachate at Site O North, Site Q North, and Site R.
- Minimize the potential for the infiltration of surface water to prevent the generation of leachate and the associated risks at Site O North, Site Q North, and Site R.
- Minimize the potential for the discharge of groundwater containing chemicals of concern which could cause an adverse ecological impact to the Mississippi River downgradient of Site R.

Identification and Analysis of Remedial Action Alternatives

Separate alternatives were developed to address soil at each site as well as site-wide groundwater. Several of the SA2 Sites require no further evaluation since no risk to human health or the environment was identified. As a result, no remedial action alternatives are developed for them. These areas include the following:

- Site P
- Site Q Central
- Site Q South.

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The sites for which remedial action alternatives were evaluated include:

- Sites O and O North
- Site Q North
- Site Q Ponds
- Site R
- Site S.

Alternatives for soil at the SA2 Sites are developed to address the specific human health and ecological risks and the RAOs presented above.

Development of Alternatives for Soils

Alternatives were developed to address impacted soil and other source material at the SA2 Sites. Presumptive remedies identified by USEPA for several types of sites and contaminants were considered in the alternative development process. Presumptive remedies are preferred technologies for common categories of sites based on historical experience. The objective of presumptive remedies is to use clean-up techniques shown to be effective in the past to expedite site investigations and the selection of remedial actions in the future.

The USEPA guidance for municipal landfill sites (USEPA, 1993c), and military landfills (USEPA, 1996), are considered applicable for the SA2 Sites and are relevant to the analysis present herein. The presumptive remedy guidance for CERCLA municipal landfill sites indicates that, waste in CERCLA landfills usually is present in large volumes and is a heterogeneous mixture of municipal waste frequently co-disposed with industrial and/or hazardous waste. Because treatment usually is impracticable, USEPA generally considers containment to be the appropriate response action, or the "presumptive remedy" for the source areas of municipal or military landfill sites.

Although the SA2 Sites are not CERCLA municipal landfills or military landfills, they possess similar characteristics and their size, volume, and mixture of waste types and contaminants makes it impractical to excavate most of them. USEPA has indicated that although no set excavation volume limit exists, landfills with contents of more than 100,000 cubic yards would not normally be considered for excavation (USEPA, 1996). Site O and O North (603,000 cubic

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yards), Site Q North (1,077,000 cubic yards), and Site R (883,000 cubic yards) all far exceed 100,000 cubic yards of contents.

Use of the presumptive remedy eliminates the need for the initial identification and screening of alternatives during the feasibility study (FS). Section 300.430(e)(1) of the NCP states that, "...the lead agency shall include an alternatives screening step, when needed, (emphasis added) to select a reasonable number of alternatives for detailed analysis." Although Sites O and O North, Q North, and R clearly meet the criteria for implementation of a conditional remedy, an alternative development and screening process was completed to further assess remedial action alternatives, and is presented below.

Screening of Potential Soil Alternatives

The process of developing remedial action alternatives for the SA2 Sites included analysis of a conditional remedy and screening of several potential alternatives. Additional alternatives were evaluated to identify those that may be implementable at the site. A list of potential alternatives was developed and then screened to identify alternatives for which a detailed and comparative analysis would be completed. Potential alternatives which undergo the initial screening process include the following:

- No Action
- Institutional Controls
- In-Situ Treatment
- Capping or Covering the Site
- Excavation and On-Site Disposal
- Excavation and Off-Site Disposal.

Based on the screening process the following alternatives were screened from further consideration:

- In-situ treatment
- Excavation and on-site disposal (except Site S)

A description of this screening evaluation is presented below.

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In-Situ Treatment

In-situ treatment of contaminated material at the SA2 Sites could include stabilization, chemical oxidation, biological treatment, soil vapor extraction (SVE) or other.

For SA2 Sites O and O North, Q North, R, and S, several factors indicate that in-situ treatment is not likely implementable at the Site. These include the following:

- With sizes ranging from 24 –53 acres the implementation of in-situ treatment at Sites O and O North, Q North, and R becomes impractical and difficult to implement and maintain.
- The mixture of waste types and contaminants including VOC, SVOCs, PCBs, dioxins/furans, and heavy metals and the heterogeneity of the material at most of the sites would make in-situ treatment inefficient and difficult to implement, and removal of COCs to the extent necessary to meet RAOs for the site is very unlikely. Delivery of treatment reagents in a heterogonous mixture of waste materials and COCs is not likely feasible and would present significant risks to site workers due to potential chemical incompatibility risks. It is unlikely that in-situ treatment could remove enough contaminant mass to meet the RAOs or significantly reduce the time required to meet groundwater standards and the sites would have to be capped following in-situ treatment.

Excavation and On-Site Disposal

Excavation, some treatment, and on-site disposal are also a potential remedial action alternative for soils at the SA2 Sites. Since the sites contain materials which could be classified as hazardous waste, the disposal cell or cells would have to comply with RCRA Subtitle C requirements and the Toxic Substances Control Act for PCBs. This alternative can be screened out here from further consideration due to implementability and other concerns. Construction of an on-site disposal cell for the contents of all the SA2 Sites would require a large landfill and construction of a cap. The process of excavating, moving and landfilling of an estimated 3.5 million cubic yards of material would present significant short-term risks at the site and in the area. This alternative would require on-site treatment prior to disposal of an estimated 875,000 cubic yards of soil which would take over five years to complete at an estimated daily production rate of 500 cubic yards per day. Sequencing of landfill construction, soil excavation and treatment, and placement in the landfill would be extremely difficult to implement. If smaller,

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individual on-site disposal cells were constructed at each site, the site would have to be excavated and the soil stockpiled or treated while the landfill was being constructed. Because of the nature of soils at these sites, long-term storage is not implementable at the SA2 Site except for Site S, which is smaller and on-site disposal may be feasible.

General Description of Soil Alternatives

Three alternatives have been developed for SA2 Sites (O and O North, Q North, and R) which are very large and where excavation and/or in-situ treatment is impractical. For Site S and the Q Ponds area, site specific alternatives are developed since those sites do not meet the size or other criteria for a presumptive remedy. Presented below is a description of the three alternatives which are applicable for the large sites where a presumptive remedy is potentially appropriate. These alternatives include:

- No Action
- Capping or Covering
- Excavation, Treatment, and Off-site Disposal of Soil/Waste Material.

No Action

The No Action Alternative (as required by the NCP) is included for comparative purposes with the active alternatives developed for the site. This alternative assumes that no further investigation, corrective action or monitoring will be completed at the SA2 Sites. The no action alternative serves as a baseline to evaluate the conditions at each site if no further actions to minimize risk to human health or the environment were taken.

Capping/Covering

This alternative would involve placing either a RCRA/TSCA compliant cap or cover over the individual sites to limit exposure to impacted soils and to minimize infiltration of surface water. A cover could include an engineered soil cover or soil and geotextile cover. For sites where hazardous waste is known to be present, a RCRA cap would be placed over the site. For sites where PCBs are present, TSCA requirements also apply. The areas addressed by this alternative do contain hazardous waste and/or PCBs so a RCRA/TSCA compliant cap (RCRA cap) is assumed for each site. The cap can include an asphalt or soil cover depending on the expected

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future use of the site and topography. A general description of the proposed cap is presented below.

The approximate size of each SA2 Site which would be capped is summarized below:

- Site O and O North: 32 acres
- Site Q North: 53 acres
- Site R: 24 acres
- Site S: 0.8 acres.

Excavation Treatment and Off-site Disposal of Soil/Waste Material

This alternative was evaluated for each of the SA2 Sites except for Site Q Ponds. Excavation and on-site disposal is not evaluated since a capping alternative is already being evaluated which would close the fill areas in place and would not require excavation of millions of cubic yards of waste material. The only reason to excavate the fill areas would be if the material was to be removed from the site.

This alternative would involve excavation of the sites where hazardous waste has been identified, including Sites O and O North, Q North, R, and S and disposing of the excavated material in an off-site hazardous disposal facility or facilities. Since PCBs are present in some SA2 Sites, disposal facilities must also be permitted to dispose of PCB containing materials. Estimates of the volume of hazardous soils and waste material which would require excavation and disposal are summarized below:

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Summary Waste Volumes Sauget Area 2				
Site	Areal Extent (square feet)	Depth (feet)	Total In-Place Volume (Cubic Yards)	Total Loose Volume (Cubic Yards)
O & O North	1,357,475	12.0	603,321	814,483
Q North	2,271,708	12.8	1,076,957	1,453,892
R	1,045,960	22.8	883,254	1,192,393
S	35,684	8.5	11,234	15,166
Totals			**2,574,766**	**3,475,934**

Detailed Evaluation Criteria for Soil Alternatives

The remedial action alternatives developed for the Site were evaluated according to the following criteria:

Primary Criteria

- Overall Protection of Public Health and the Environment
- Compliance with ARARs and other Criteria, Advisories, and Guidance

Balancing Criteria

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment
- Short-term effectiveness
- Implementability
- Cost.

Summary of the Comparative Analysis

Site O and O North

A summary of the comparative analysis and total ranking for each component of the alternative for Site O and O North is presented below:

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Site O and O North	No Action	Alternative 2 Install RCRA Cap	Alternative 3 Excavate, Treat and Dispose Off-Site
Overall Protection of Public Health and the Environment	2	1	3
Compliance with ARARs	3	2	1
Short-Term Effectiveness	2	1	3
Implementability	1	2	3
Long-Term Effectiveness and Permanence	3	2	1
Reduction of Toxicity	3	2	1
Cost	1 ($0)	2 ($7.8 MM)	3 ($562 MM)
Cumulative Score	15	**12**	15

Based on the detailed evaluations, installing a RCRA cap over Site O and O North will protect human health and the environment and meet the RAOs developed. Capping the site is implementable and could be completed within a reasonable time frame. The estimated 30-year present worth cost for this site is $7.8 million. This alternative is consistent with presumptive remedies for municipal landfills under CERCLA and does not present significant short-term impact to the surrounding environment.

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Site Q North

A summary of the comparative analysis and total ranking for each component of the alternatives for Site Q North is presented below:

Site Q North	Alternative 1 No Action	Alternative 2 Install RCRA Cap	Alternative 3 Excavate, Treat and Dispose Off-Site
Overall Protection of Public Health and the Environment	2	1	3
Compliance with ARARs	3	2	1
Short-Term Effectiveness	2	1	3
Implementability	1	2	3
Long-Term Effectiveness and Permanence	3	2	1
Reduction of Toxicity	3	2	1
Cost	1 ($0)	2 ($12 MM)	3 ($1,000 MM)
Cumulative Score	15	**12**	15

Based on the detailed evaluations installing a RCRA cap over Site Q North will protect human health and the environment and meet the RAOs. Capping the site is implementable and could be completed within a reasonable time frame. The estimated 30-year present worth cost for this site is $12 million. This alternative is consistent with presumptive remedies for municipal landfills under CERCLA and does not present a significant short-term impact for the surrounding environment.

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Site R

A summary of the comparative analysis and total ranking for each component of the alternatives for Site R is presented below:

Site R	Alternative 1 No Action	Alternative 2 Install RCRA Cap	Alternative 3 Excavate, Treat and Dispose Off-Site
Overall Protection of Public Health and the Environment	2	1	3
Compliance with ARARs	3	2	1
Short-Term Effectiveness	2	1	3
Implementability	1	2	3
Long-Term Effectiveness and Permanence	3	2	1
Reduction of Toxicity	3	2	1
Cost	1 ($0)	2 ($6.7 MM)	3 ($823 MM)
Cumulative Score	15	**12**	15

Based on the detailed evaluations installing a RCRA cap over Site R will protect human health and the environment and meet the RAOs. Capping the site is implementable and could be completed within a reasonable time frame. The estimated 30-year present worth cost for this site is $6.7 million. This alternative is consistent with presumptive remedies for municipal landfills under CERCLA and does not present a significant short-term impact for the surrounding environment.

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Site S

A summary of the comparative analysis and total ranking for each component of the alternatives for Site S is presented below:

Site S	Alternative 1 No Action	Alternative 2 Install RCRA Cap	Alternative 3 Excavate, Treat and Dispose Off-Site	Alternative 4 Excavate, Treat and Dispose On-Site
Overall Protection of Public Health and the Environment	4	1	2	3
Compliance with ARARs	4	3	2	1
Short-Term Effectiveness	2	1	4	3
Implementability	1	2	3	4
Long-Term Effectiveness and Permanence	4	3	1	2
Reduction of Toxicity	4	3	1	2
Cost	1 ($0)	2 ($0.36MM)	3 ($10.5 MM)	4 ($11.4 MM)
Cumulative Score	20	**15**	16	19

The No Action alternative would not be protective of human health or the environment. Alternatives 2, 3, and 4 would be protective of human health and the environment and would meet the RAOs.

Site Q Ponds

The Site Q Ponds are significantly different from the other SA2 Sites. The only risk identified for this site is associated with potential consumption from fish that may be present seasonally in the ponds following a flood event. Alternatives to address these ponds, which will undergo detailed evaluation, include the following:

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- No Action
- Institutional Controls
- Constructed Wetlands
- Pond Liner
- Pond Filling.

A summary of the comparative analysis and total ranking for each criteria of the alternatives considered for Site Q Ponds is presented below:

Site Q Ponds	Alternative 1 No Action	Alternative 2 Institutional Controls	Alternative 3 Constructed Wetlands	Alternative 4 Pond Lining	Alternative 5 Pond Filling
Overall Protection of Public Health and the Environment	5	4	1	3	3
Compliance with ARARs	5	3	1	2	4
Short-Term Effectiveness	1	2	3	5	4
Implementability	1	2	5	4	3
Long-Term Effectiveness and Permanence	5	3	2	4	1
Reduction of Toxicity	5	4	2	3	1
Cost	1 ($0)	3 ($0.19MM)	5 ($2.9 MM)	4 ($1 MM)	2 ($0 MM)
Cumulative Score	23	21	19	25	**18**

For the Q Ponds site, all of the alternatives except Alternative 1 would meet the remedial action objectives and protect human health and the environment. Institutional controls could be implemented to meet the corrective action objectives and protect human health and the environment and is the most cost effective solution to meet the RAOs. The estimated 30-year present worth cost estimate for Alternative 2 is $189,000. Fencing the site and posting warning

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signs would significantly reduce the incidence of fish consumption. Flood events would likely impact the fence and long-term repair and maintenance would be required. Alternative 5 would not have a cost if the current landowner fills the ponds with construction debris. If fill is brought in from off-site the cost is estimated at $7.4 million.

Description and Detailed Analysis of Groundwater Alternatives

The RAOs for the SA2 Sites groundwater were formulated based on environmental concerns defined in the HHRA and the BERA. One of the key factors in the outcome of the HHRA is that the use of groundwater in the vicinity of the SA2 Site as a drinking water source is prohibited. As a result, the HHRA evaluated potential incidental exposures to groundwater (i.e., non-drinking water scenarios) including contact by a construction/utility worker performing excavation in the area or volatilization through the soil column resulting in exposure to chemicals of concern in indoor or outdoor air.

With respect to the groundwater at the SA2 Sites, the key findings of the risk assessments were as follows:

- No risks to human health from exposure to groundwater were identified in the HHRA
- The only ecological risk identified was to the surface water in the area west of SA2 Sites, Site R, where groundwater discharges to the Mississippi River.

The streamlined feasibility study for groundwater was developed to identify and screen remedial alternatives that are potentially suitable for ensuring adequate protection of human (public) health and the environment considering the specific groundwater conditions and risks at SA2.

The following alternatives were developed to address impacted groundwater at the SA2 Sites.

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Alternative	Description
Groundwater Alternative 1	No Action
Groundwater Alternative 2	Institutional Controls Monitoring – Groundwater Quality Monitoring – Bioaccumulation Monitoring
Groundwater Alternative 3	Physical Barrier at Site R Groundwater Extraction Institutional Controls Monitoring – Groundwater Quality Monitoring – Bioaccumulation Monitoring – Groundwater Level Monitoring
Groundwater Alternative 4	Physical Barrier Along Entire Western Boundary of SA2 Groundwater Extraction Institutional Controls Monitoring – Groundwater Quality Monitoring – Bioaccumulation Monitoring – Groundwater Level Monitoring
Groundwater Alternative 5	Hydraulic Containment and Groundwater Extraction Along Entire Western Boundary of SA2 Groundwater Extraction Institutional Controls Monitoring – Groundwater Quality Monitoring – Bioaccumulation Monitoring – Groundwater Level Monitoring

It is noted that an interim remedy (consistent with Alternative 3 herein) is currently being constructed at the site. The interim remedy includes a 3,300-foot long U-shaped slurry wall downgradient of SA2 Site R. The interim remedy also includes three groundwater extraction wells upgradient of the slurry wall. For the purpose of this streamlined feasibility study, the evaluation of the remedial alternatives was conducted as if the interim remedy was not present at the site. Therefore, the effects of the slurry wall and extraction wells were not considered in the analysis of the No Action and Institutional Controls alternatives.

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Groundwater Alternative 1 - No Action

The no action alternative would assume that no additional investigation, monitoring, or remedial actions would be completed at the SA2 Sites. This alternative is required by the NCP to provide a baseline for comparison of each alternative and to evaluate the conditions at the site if no action to minimize risk to human health or the environment were taken.

Groundwater Alternative 2 – Institutional Controls and Monitoring

Institutional Controls

Institutional controls can include access restrictions to the area of interest, as well as regulations restricting specific activity within the area of interest. This alternative is intended to mitigate potential exposure to contaminated groundwater. The institutional controls may include, but not limited to, the following:

- Access Restrictions
- Warning Signs
- Deed Restrictions
- Use Restrictions
- Community Relations.

One significant institutional control has already been established at the Site. The Villages of Sauget and Cahokia have issued ordinances that prohibit the use of groundwater as a potable water source. These ordinances were issued in response to historic industrial use in the region, and resulting groundwater quality impairments.

Access and Deed restrictions are considered relatively difficult to implement at the SA2 site due to the multiple property owners in the area. Access restrictions already in place at Site R include fencing to control access and excavation restrictions to prevent trenching without appropriate protection of construction workers.

Monitoring

Groundwater Alternative 2 includes a well-designed monitoring program. The monitoring program will consist of two primary components; groundwater quality monitoring and bioaccumulation monitoring.

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Groundwater Quality Monitoring

Groundwater monitoring will be conducted in the area of the SA2 Sites. The exact number and location of wells in the groundwater monitoring network will be established during the remedial design. However, it is assumed that the monitoring system will include wells screened in the shallow, intermediate, and deep groundwater zones at SA2 Sites.

For the purpose of the evaluation, it was assumed that the groundwater monitoring program will be conducted for 30 years and will consist of 18 Clusters (54 wells) sampled semiannually.

For the cost estimates, it is assumed that 18 new well clusters will be installed as part of the monitoring network.

Bioaccumulation Monitoring

Bioaccumulation monitoring will be conducted on an annual basis. Bottom-feeder fish tissue samples will be collected in the plume discharge area downgradient of SA2 Sites O, Q North, R, and S to determine if any contaminants discharging to the Mississippi River are accumulating in fish tissue. Bottom feeding fish are considered the appropriate trophic level to sample and monitor for bioaccumulation in a situation where impacted groundwater discharges to surface water. Focusing on bottom feeders also reduces the complexity and difficulty of sampling and analyzing fish tissue samples from all three trophic levels (bottom feeder, forager, and predator).

Groundwater Alternative 3 - Physical Barrier at Site R, Institutional Controls, and Monitoring

Groundwater Alternative 3 includes the elements of Alternative 2 (institutional controls and monitoring) coupled with the installation of an engineered physical barrier (slurry wall) adjacent to Site R. The purpose of the slurry wall is to prevent discharge of contaminated water from Site R to the Mississippi River. The ecological risk assessment identified an ecological risk to the Mississippi River associated with discharge of groundwater to the river at this location. This alternative is designed to mitigate this risk.

Physical Barrier and Groundwater Extraction Wells

This alternative is currently being implemented as an interim remedy at SA2 Site R in accordance with the Unilateral Administrative Order (V-W-02-C-716) dated October 3, 2002. A 3-foot wide, 3,300-foot long slurry wall is currently being installed to a depth of approximately 140 feet below ground surface (bgs) downgradient of Site R.

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Three groundwater extraction wells have been installed and are being operated at a combined extraction rate of up to 1,800 gpm. The extraction rate will be decreased once the construction of the slurry wall is complete in the first quarter of 2004. Groundwater modeling indicates that the three extraction wells will be operated at a combined flow rate of 535 gpm at average Mississippi River flow.

All of the extracted groundwater will be treated at the American Bottoms Regional Treatment Facility (ABRTF).

Institutional Controls

The institutional controls for this alternative are as described above for Alternative 2.

Monitoring

Groundwater Quality Monitoring

The groundwater quality monitoring program for Alternative 3 will be the same as described for Alternative 2. However, four of the monitoring well clusters will be installed immediately downgradient of the barrier wall. The purpose of these wells is to facilitate monitoring the performance of the slurry wall.

The sampling frequency and the analytical parameters (including the wells downgradient of the barrier wall) will be the same as described for Groundwater Alternative 2.

Groundwater Level Monitoring

Groundwater level monitoring will be performed to ensure acceptable performance of the physical barrier installed to abate the impact of groundwater discharging to surface water.

Groundwater levels will be monitored at the physical barrier to determine if gradient control is achieved. Gradient control will be determined by comparing the water-level elevations in one pair of fully penetrating water-level piezometers installed in the northwest corner of the physical barrier and one pair installed at its southwest corner. One piezometer of each pair will be installed inside the barrier wall and one will be installed outside it. Pumping rates will be adjusted so that the water-level elevation in the inside piezometer at each corner of the barrier wall is the same as the water-level elevation in the outside piezometer. This will ensure that groundwater discharging to the physical barrier is controlled.

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Bioaccumulation Monitoring

The bioaccumulation monitoring will be will be the same as described for Alternative 2 above.

Groundwater Alternative No. 4 – Physical Barrier Along Entire Length of Area 2, Institutional Controls, and Monitoring

Groundwater Alternative 4 includes the elements of Alternative 2 (institutional controls and monitoring) coupled with installation of a physical barrier along the entire western side of Area 2, adjacent to the Mississippi River. The purpose of the barrier is to prevent discharge of contaminated groundwater to the Mississippi River.

The ecological risk assessment (Menzie-Cura and Associates, 2001) identified a risk associated with discharge of groundwater to the Mississippi River at the location of Site R. This alternative is designed to mitigate this risk. Although the concentrations do not present an ecologic risk, this alternative also prevents the discharge of groundwater with contaminant concentrations above Illinois Class I Groundwater Standards. Groundwater exceeding these standards is present throughout the SA2 area, however risk to human health is limited because the water is not used as a drinking water source and the concentrations do not present an ecological risk.

Physical Barrier and Groundwater Extraction Wells

The barrier wall included in Groundwater Alternative 4 would be approximately 12,000-foot long, 3 feet wide, approximately 140 feet bgs. The wall would be installed along the Mississippi River, adjacent to the entire western side of the SA2 sites. Construction of a barrier wall of this length will require excavation and disposal of approximately 273,000 cubic yards of potentially contaminated materials from the trench. It is assumed that the excavated material would be temporarily stockpiled at the SA2 Site nearest to where the excavated material was generated. Groundwater extraction wells would be installed upgradient of the barrier wall. The purpose of the extraction wells is to abate the discharge of groundwater to the wall. The estimated combined flow rate from the extraction well system is 3,000 gpm. This estimate is based on the volume of groundwater that enters the barrier wall and does not include extraction of any groundwater in excess of the natural flow rate to the wall.

All of the extracted groundwater will be treated at the ABRTF.

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Institutional Controls

The institutional controls for this alternative are as described above for Alternative 2.

Monitoring

Groundwater Quality Monitoring

The groundwater quality monitoring program for Alternative 4 will be the same as described for Alternative 2. However, eighteen monitoring well clusters spaced approximately 667 feet apart will be installed on the downgradient side of the barrier wall. The purpose of these wells is to facilitate monitoring the performance of the barrier wall. Groundwater quality samples will collected downgradient of the slurry wall to determine mass loading to the Mississippi River resulting from any contaminants through, past, or beneath the wall. The sampling frequency and the analytical parameters (including the wells downgradient of the barrier wall) will be the same as described for Groundwater Alternative 2.

Groundwater Level Monitoring

Groundwater level monitoring will be performed to ensure acceptable performance of the physical barrier. Groundwater levels will be monitored at the physical barrier to determine if gradient control is achieved. Gradient control will be determined by comparing the water-level elevations in six fully penetrating water-level piezometers installed inside or upgradient of the physical barrier to water levels in corresponding monitoring well clusters on the outside or downgradient side of the barrier wall. Pumping rates will be adjusted so that the water-level elevation in the piezometers inside the barrier wall is the same as the water-level elevation in the monitoring wells outside the barrier wall. This will ensure that groundwater discharging to the physical barrier is controlled.

Bioaccumulation Monitoring

The bioaccumulation monitoring will be will be the same as described for Alternative 2 above.

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Groundwater Alternative No. 5 – Hydraulic Containment through Aggressive Pumping Along Entire Length of Area 2, Institutional Controls, and Monitoring

This alternative includes the elements of Alternative 2 (institutional controls and monitoring) coupled with hydraulic containment / aggressive extraction of the contaminated groundwater along the entire western side of Area 2, adjacent to the Mississippi River. The potential benefits of this alternative are twofold. First, the alternative would provide hydraulic control and prevent discharge of groundwater containing contaminants above the Illinois Class I Groundwater Standards to the Mississippi River. Secondly, this alternative would include extraction of groundwater at the maximum sustainable rates. This aggressive extraction would increase the groundwater flow rate through the contaminated source areas in Area 2 and would therefore result in a shorter cleanup time.

The system would include installation and operation of 24 groundwater extraction wells spaced approximately 500 feet apart on the west side of the SA2 Sites adjacent to the Mississippi River. The estimated maximum sustainable flow rate from each well is 1,100 gpm. The combined extraction rate would be 26,400 gpm.

The groundwater extraction rate of 26,400 gpm or approximately 38 million gallons per day (MGD) would exceed the current capacity of the ABRTF. Therefore, Groundwater Alternative 5 would require construction of a treatment facility to manage an additional 26 MGD (38 MGD extracted groundwater minus the 12 MGD that could be treated at the ABRTF). It is assumed that the capitol cost to construct the facility will be recovered over time and is included in the $5/per gallon treatment cost used in the estimate.

Institutional Controls

The institutional controls for this alternative are as described above for Alternative 2.

Monitoring

Groundwater Quality Monitoring

Eighteen monitoring well clusters will be installed approximately 667 feet apart, along the Mississippi River, downgradient of the line of 24 extraction wells. The purpose of these wells is to facilitate monitoring the performance of the groundwater extraction system.

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The sampling frequency and the analytical parameters (including the wells downgradient of the barrier wall) will be the same as described for Groundwater Alternative 2.

Groundwater Level Monitoring

Groundwater level monitoring will be performed to ensure acceptable performance of the hydraulic containment / aggressive extraction system. For this alternative, the objective is to remove groundwater at the maximum sustainable flow rate, rather than to optimize flow rates necessary to achieve hydraulic control and/or remove water entering a barrier (as in Alternatives 3 and 4). Therefore, the groundwater levels in the aquifer at locations away from the extraction wells are not as critical to the success of this alternative. Rather, the drawdown in individual extraction wells will be monitored and adjusted to achieve maximum extraction rates. Therefore, the conceptual layout of this alternative does not include additional water level piezometers in the vicinity of the extraction system.

Demonstration and monitoring of hydraulic control at the western edge of SA2 will be based on routine water level measurements in the monitoring well clusters that are part of the overall groundwater quality monitoring network.

Bioaccumulation Monitoring

The bioaccumulation monitoring will be will be the same as described for Alternative 2 above.

Summary of the Detailed Evaluation

Detailed evaluations of each of the five alternatives for groundwater were conducted. The alternatives were evaluated with respect to the two primary criteria and five balancing criteria described above. Cost estimates for each alternative including Capital Cost, Annual Operation and Maintenance Cost (if any), and a 30-year Present Worth Cost were developed.

Summary of the Comparative Analysis

In the following sections, Groundwater Alternatives 1 through 5 are compared to one another to identify the relative advantages and disadvantages of each. A forced ranking system was used to identify the alternatives that best achieves the requirements of the seven evaluation criteria used to evaluate remedial alternatives. This analysis ranks each alternative against the others, with the low score representing the best alternative for achieving the specific criterion. Each component

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of the alternatives is given a ranking of 1 through 5 for each criterion representing the best alternative to address the criteria (ranking of 1) to the least effective (ranking of 5). The scoring is based on engineering judgment based on review of the site conditions and professional judgment. The summary scores are presented at the end of this section.

Overall Protection of Public Health and the Environment

Alternative 1 does not provide for additional protection of human health or the environment. Alternative 2 is protective of human health. The institutional controls associated with the ordinances against use of groundwater as a drinking water source are protective and result in no risk to human health associated with the groundwater at the site. However, Alternative 2 does not address the ecological risk associated with discharge of groundwater to the Mississippi River at the location of Site R.

Alternatives 3, 4, and 5 are protective of human health and the environment. All three alternatives include institutional controls to protect human health and also include components that prevent discharge of groundwater at Site R and therefore mitigate the ecological risk to the Mississippi River at this location. However, since the only ecological risks were related to discharge downgradient of Site R, Alternative 3 provides equal risk protection at a lower cost.

Short-Term Effectiveness

Groundwater Alternatives 1 and 2 do not include short-term risks to remedial workers as the alternatives would be implemented. However, both alternatives would result in a short-term risk to the environment since they do not include elements to address the risk associated with groundwater discharge to the Mississippi River. Both alternatives rely on natural processes to reduce the adverse ecological impacts resulting from groundwater discharge to surface water. Natural processes will not reduce adverse impacts on the Mississippi River in the short term.

Groundwater Alternative 4 could be implemented in a reasonable time frame. Short term risks to remedial workers during installation of a physical barrier and extraction wells along the western side of SA2 Site could be managed. Alternative 5 is considered the poorest option with respect to short-term effectiveness. This alternative includes extraction and treatment of an extremely large volume of contaminated groundwater on a daily basis. Treatment of this water would require significant efforts to manage the short-term risks to remedial workers conducting the on site operation and maintenance activities and to the treatment plant operators.

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Groundwater Alternative 3 presents the best alternative with respect to short-term effectiveness. The most important factor leading to this conclusion is that Groundwater Alternative 3 is already being installed as an approved interim remedy at the site. Construction of the 3,300-foot long slurry wall is scheduled to be completed the first quarter of 2004. The extraction wells associated with this alternative are already installed and are being operated to maintain hydraulic control of the groundwater downgradient of Site R. Construction of the barrier wall at Site R will mitigate the ecological risk associated with discharge of groundwater to the river.

Implementability

Groundwater Alternative 1 (No Action) is the easiest to implement as nothing more is required. However, Groundwater Alternative 3 is currently being implemented and all applicable permits and permissions are in place. The extraction wells have been installed and treatment of the extracted groundwater at the ABRTF has commenced. All of the principal technical challenges and planning decisions have been finalized for this alternative.

Groundwater Alternative 2 could be implemented relatively easily from a technical standpoint, it is unlikely that this alternative would be acceptable to the agencies involved or to the public.

Groundwater Alternatives 4 and 5 could be implemented from a technical standpoint, each alternative would include significant challenges that would require careful consideration and upfront planning. The primary challenge with Alternative 4 would be the disposal of the 273,000 cubic yards of spoils or cuttings during installation of the physical barrier. Groundwater Alternative 5 would include construction of a wastewater treatment plant and would require significant planning to manage the treatment of approximately 38 million gallons of groundwater on a daily basis.

Compliance with ARARs and Other Criteria, Advisories, and Guidance

Illinois Class I Groundwater Standards and federal MCLs are appropriate ARARs for SA2 groundwater. 35 IAC 620.250 provides for the establishment of a groundwater management zone, wherein alternate water quality standards are allowed in accordance with 35 IAC 620.450. Each of the five alternatives for the SA2 Site groundwater is compliant with ARARs.

Long-Term Effectiveness and Permanence

Groundwater Alternatives 1 and 2 provide no long term effectiveness or permanence.

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Alternatives 3, 4, and 5 include extraction and treatment of groundwater. Each of these alternatives provides a long term, effective solution for managing the risks associated with the SA2 Site Groundwater. Groundwater Alternatives 3 and 4 provide an added benefit of the installation of a permanent barrier wall that will impede discharge of groundwater to the Mississippi River.

The analysis presented in Appendix M includes a relative comparison of the remediation timeframes for each of the five groundwater alternatives. Planning level source lifetime calculations predict that groundwater remediation timeframes will be up to 351 years. Groundwater Alternatives 1 through 4 do not decrease the remediation timeframe since the groundwater flow rates through contaminated areas would be the same as the rate under natural conditions. Intensive groundwater pumping associated with Alternative 5 generally shortens the remediation timeframe by approximately 60 percent. Site R is expected to have the longest remediation timeframe, with 351 years predicted for Alternatives 1 through 4 and 140 years for Alternative 5.

Reduction of Toxicity, Mobility, or Volume through Treatment

Groundwater Alternatives 1 and 2 rely on natural processes to reduce the toxicity, mobility, and volume of contaminants. Alternatives 3 and 4 reduce the mobility of groundwater contaminants by physical control and removal of affected groundwater before it discharges to the Mississippi River.

Although the groundwater along the entire western side of the SA2 sites does contain contaminants at concentrations above Illinois Class I Groundwater Standards, greater than 99 percent of the total estimated contaminant mass at SA2 is associated with Site R. Therefore, the slurry wall and groundwater extraction system included in Alternative 3 (currently being installed as an interim remedy at the site) are expected to capture over 99 percent of the overall contaminant mass being discharged from SA2. Alternatives 4 and 5 include elements that significantly reduce or prevent discharge of groundwater to the river along the entire length of the SA2 Site, but do not provide significant additional mass removal.

With Alternative 5, groundwater will be extracted and treated at a rate of 26,400 gpm. This flow rate is approximately 8.7 times the natural groundwater discharge rate to the Mississippi River. Extraction and treatment of groundwater at this aggressive rate will result in the treatment of

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approximately 13.9 billion gallons of groundwater on an annual basis and an overall decrease in the cleanup time from 350 years to 140 years. Treatment of this water will result in an overall decrease in the toxicity, mobility, or volume of contaminants discharging to the Mississippi River.

Cost

No costs are associated with Alternative 1. Costs associated with Alternatives 2, 3, 4, and 5 are summarized below:

Alternative 2 - $5,825,578

Alternative 3 - $31,373,208

Alternative 4 - $136,302,089

Alternative 5 - $873,964,884

Based on the information presented above, a summary of the comparative analysis and total ranking for each component of the five alternatives is presented in the following table.

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
	No Action	Institutional Controls	Physical Barrier at Site R	Physical Barrier Along Area 2	Hydraulic Containment Along Area 2
Overall Protection of Public Health and the Environment	5	4	3	1	2
Compliance with ARARs	5	4	3	2	1
Short-Term Effectiveness	2	3	1	4	5
Implementability	1	3	2	4	5
Long-Term Effectiveness and Permanence	5	4	1	2	3
Reduction of Toxicity	5	4	2	3	1
Cost	1 ($0)	2 ($5.8 MM)	3 ($31.4 MM)	4 ($136.3 MM)	5 ($877.0 MM)
Cumulative Score	24	24	**15**	20	22

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Comparative Analysis Summary

A summary of the comparative analysis and the associated cost is provided below.

Comparative Analysis Results – Source Control Remedies		
Sites O and O North	RCRA/TSCA Cap	$ 7.8MM
Site Q North	RCRA/TSCA Cap	12.0MM
Site R	RCRA/TSCA Cap	6.7MM
Site S	RCRA/TSCA Cap	0.36MM
	Subtotal	**$26.9MM**
Comparative Analysis Results – Groundwater Control Remedy		
Groundwater	Physical Barrier and Groundwater Extraction at Site R	31.4MM
	Total	**$58.3MM**

SECTIONONE Sites Description and Background

On November 20, 2000, the SA2SG PRPs signed an AOC, Docket Number V-W-01-C-622, to perform a RI/FS at five waste disposal sites known as SA2 Sites O, P, Q, R and S. USEPA Region V signed the AOC on November 24, 2000. This RI/FS report is submitted to partially fulfill the requirements of Section V.2, Work to be Performed, of the AOC.

The SA2 Sites are located in the City of East St. Louis and the Villages of Sauget and Cahokia in St. Clair County, Illinois. The SA2 study area is east of the Mississippi River and south of the MacArthur Bridge railroad tracks. The study area is west of Route 3 (Mississippi Avenue) and north of Cargill Road. The five sites, the former uses of the sites and the municipalities in which the sites are located are summarized below.

Sites	Former Use	Municipality
Site O	Sewage Sludge Dewatering	Village of Sauget
Site P	Municipal and Industrial Waste Disposal	City of East St. Louis Village of Sauget
Site Q	Municipal and Industrial Waste Disposal	Village of Sauget Village of Cahokia
Site R	Industrial Waste Disposal	Village of Sauget
Site S	Chemical Reprocessing Waste Disposal	Village of Sauget

These sites are located in an area historically used for heavy industry, including chemical manufacturing, metal refining, power generation, and waste disposal. Currently the area is used for heavy industry, warehousing, bulk storage (coal, refined petroleum, lawn and garden products and grain), wastewater treatment, hazardous waste treatment, waste recycling and truck terminals. Four commercial establishments are located at the north end of the study area. No residences are located within the study area. Residential areas closest to SA2 Sites are approximately 3,000 feet east of Site P and about 3,000 feet east of Site O. These residential areas are located, respectively, in East St. Louis and Cahokia.

1.1 SITES LOCATION AND PHYSICAL SETTING

SA2 Sites consists of five former disposal areas, Sites O, P, Q, R and S, adjacent, or in close proximity, to the Mississippi River. These five disposal areas were given letter designations by

the IEPA in the 1980s. Two of these sites, Sites Q and R, are located on the wet side (i.e., west) of the floodwall and levee which is operated and maintained by the U.S. Army Corps of Engineers (USACE) and the Metro East Sanitary District. The floodwall is designed to protect the City of East St. Louis and the Villages of Sauget and Cahokia from flooding. Sites O, P and S are located on the dry side (i.e., east) of the floodwall and levee. The SA2 Sites are located in the floodplain of the Mississippi River in an area known as the American Bottoms. Topographically, the area consists primarily of flat bottomland although local topographic irregularities do occur. Generally, land surface in the American Bottoms slopes from north to south and from east to west toward the Mississippi River. Land surface elevation ranges from 400 to 410 feet above Mean Sea Level (MSL).

1.1.1 Description of Site Boundary Modifications

The Field Sampling Plan (FSP) (URS, 2002b) identified a number of activities to be completed prior to undertaking the collection of samples from the various sites for laboratory analysis. The output from several of these preliminary activities was then used to modify, where appropriate, the site boundaries as described in the AOC. One such activity was the review of historical aerial photographs that were not available at the time of the 1988 Ecology & Environment Report, when the original site boundaries were defined. As a result of this review, additional areas were identified that were associated with Site O that were added to the investigative program. These areas were identified as O North and O South.

Additionally, a magnetometer survey was undertaken at Sites P, Q, R, and S and a soil gas survey was undertaken at Sites O, P, Q, R and S prior to the collection of environmental samples. Based on the results of these surveys, as well as visual site reconnaissance activities and the aerial photo review discussed above, Site Q was divided into three sub-areas for the purpose of the RI. This decision was based on the current and historical land uses of the various portions of Site Q, which allowed for a logical subdivision of the site. These three sub-areas were identified as Q North, Q Central, and Q South.

The HHRA and the BERA indicated that the ponds located in the southern portion of Site Q (Q South) represented a significantly different exposure potential than the surrounding non-pond area of Q South. As a result, the ponds were treated as a separate area, identified as Q Ponds, for the HHRA, the BERA, and FS.

1.2 PRESENT AND PAST FACILITY OPERATIONS AND DISPOSAL PRACTICES

Each of the five sites in SA2 Sites is described below. Maximum chemical concentrations included in these site descriptions were included by USEPA in the AOC.

1.2.1 Site O

Site O, located on Mobile Avenue in Sauget, Illinois, occupies approximately 20 acres of land to the northeast of the American Bottoms Regional Wastewater Treatment Facility (ABRTF). An access road to the ABRTF runs through the middle of the site. In 1952, the Village of Sauget Waste Water Treatment Plant began operation at this location. In addition to providing treatment for the Village of Sauget, the plant treated effluent from the various Sauget industries.

During its operation the treatment plant received and treated industrial and municipal wastewater. Approximately 10 million gallons per day of wastewater was treated, most of which was from area industries.

Four lagoons were constructed at the wastewater treatment plant in 1965 and placed in operation in 1966/1967. Between 1966/67 and approximately 1978, these lagoons were used to dispose of clarifier sludge from the wastewater treatment plant. The lagoons were designated as Site O during a site investigation conducted by IEPA in the 1980s. The lagoons were closed in 1980 by stabilizing the sludge with lime and covering it with approximately 2 feet of clean low-permeability soil. Currently, the lagoons are covered with clean low-permeability soil and are vegetated.

Parties that EPA alleges discharged to the Sauget Wastewater Treatment Plant during the time period that the sludge lagoons were in operation included, at a minimum:

- Amax Zinc Corporation,
- American Zinc Company
- Cerro Copper Products Company
- Clayton Chemical Co.
- Darling Fertilizer
- Ethyl Petroleum Additives, Inc.
- Midwest Rubber Reclaiming
- Mobil Oil Corporation
- Monsanto Company
- Rogers Cartage Company
- Wiese Planning and Engineering

Parties which own and/or operate, or previously owned and/or operated, portions of Site O include:

- Village of Sauget.

1.2.2 Site P

Site P, which is bounded by the Illinois Central Gulf Railroad tracks, the Terminal Railroad Association tracks and Monsanto Avenue, and occupies approximately 20 acres of land located in the City of East St. Louis and the Village of Sauget. It was operated by Sauget and Company as an IEPA-permitted landfill from 1973 to approximately 1984 accepting general wastes, including diatomaceous earth filter cake from Edwin Cooper and non-chemical wastes from Monsanto. IEPA inspections documented the presence of drums labeled "Monsanto ACL-85, Chlorine Composition," drums labeled phosphorus pentasulfide from Monsanto and Monsanto ACL filter residues and packaging. Site P is currently inactive and partially covered, however, access to the site is not restricted.

Parties that USEPA alleges to have generated, disposed of, released into and/or transported wastes to Site P include:

- Edwin Cooper Petroleum Additives
- Kerr-McGee Chemical Company
- Monsanto Chemical Company

USEPA alleges that parties who potentially own, previously owned and/or operated Site P include:

- Cahokia Trust Properties
- Chicago Title & Trust Company
- City of East St. Louis
- Gulf-Mobile & Ohio Railroad
- Magna Trust
- Metro East Sanitary District
- Norfolk Southern
- SI Enterprises
- Sauget and Company
- Solutia
- Southern Railway System
- Union Electric Company

1.2.3 Site Q

Site Q, a former subsurface and surface disposal area, occupies approximately 90 acres in the Villages of Sauget and Cahokia. This Site is divided by the Alton and Southern Railroad into a northern portion and a southern portion. The northern portion consists of 65 acres bordered on

the north by Site R and Monsanto Avenue. The northern portion is bordered on the south by the main track of the Alton and Southern Railroad and property owned by Patgood Inc. On the east, the northern portion of the site is bordered by the Illinois Gulf Central Railroad and the USACE flood control levee and on the west the site is bordered by the Mississippi River.

The southern portion consists of 25 acres, north of Cargill Road and south of the Alton and Southern Railroad. The southern portion is bounded on the west by a 10-foot wide easement owned by Union Electric for transmission lines and a spur track of the Alton and Southern Railroad to the Fox Terminal. A barge terminal operated by St. Louis Grain Company is located between the Union Electric easement, the spur track and the Mississippi River. Southern Site Q is bordered on the east by the Illinois Central Gulf Railroad and the flood control levee.

Disposal activities at Site Q started in the 1950s and continued until the 1970s. Allegedly, Sauget and Company started operation of a landfill south of the Monsanto River Terminal in 1966 and terminated operations in 1973. This facility took various wastes including municipal waste, septic tank pumpings, drums, organic and inorganic wastes, solvents, pesticides and paint sludges. It also took plant trash and waste from other industrial facilities and demolition debris.

Most of Site Q is covered with highly permeable black cinders. Eagle Marine Industries and Peavy Company, a division of ConAgra, operate barge terminal facilities in the central part of the northern portion of Site Q. The southern portion of Site Q is used for reclaiming rebar from concrete. A 10-acre site on the northern portion of Site Q is currently used by River City Landscape Supply as a bulk storage terminal for lawn and garden products. Raw landscape products such as mulch, rock and soil are processed and packed on this portion of the site.

Access to some portions of the site is restricted by fencing and gates. Other parts of the site have unrestricted access.

Site Q is on the west side of the USACE floodwall. In 1993, during the highest recorded flood in St. Louis' history, Site Q was flooded. USEPA conducted a removal action at the northern portion of Site Q in 1995 under Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). USEPA conducted a second CERCLA removal action at the southern portion of Site Q beginning in October of 1999 and into early 2000. During this removal action, USEPA excavated over 3,200 drums and over 17,000 cubic yards of soils containing metals, polychlorinated biphenyl (PCBs), and organics. Excavated material was

transported by rail to Oklahoma for disposal at SafetyKleen's Lone Mountain hazardous waste landfill.

USEPA alleges that the following parties potentially generated, disposed of, released into and/or transported wastes to Site Q:

- AALCO Wrecking Company, Inc.
- Abco Trash Service
- Able Sewer Service
- Ajax Hickman Hauling
- Atlas Service Company
- Banjo Iron Company
- Barry Weinmiller Steel Fabrication
- Becker Iron & Metal Corporation
- Belleville Concrete Cont. Company
- Bi-State Parks Airport
- Bi-State Transit Company
- Boyer Sanitation Service
- Browning-Ferris Industries of St. Louis
- C&E Hauling
- Cargill Inc.
- Century Electric Company
- Circle Packing Company
- Clayton Chemical Company
- Corkery Fuel Company
- Crown Cork & Seal Company, Inc.
- David Hauling
- Dennis Chemical Company, Inc.
- Disposal Service Company
- Dore Wrecking Company
- Dotson Disposal "All" Service
- Dow Chemical
- Patgood
- Edgemont Construction
- Edwin Cooper Inc.
- Eight & Trendy Metal Company
- Evans Brothers
- Finer Metals Company
- Fish Disposal
- Fruin-Colnon Corporation
- Gibson Hauling
- H.C. Fournie Inc.
- H.C. Fournie Plaster
- Hilltop Hauling
- Huffmeier Brothers
- Hunter Packing Company
- Illinois Department of Transportation
- Inmont Corporation
- Lefton Iron & Metal Company
- Mallinckrodt Chemical
- Midwest Sanitation
- Mississippi Valley Control
- Monsanto Company
- Myco-Gloss
- Obear Nestor
- Roy Baur
- Thomas Byrd
- Trash Men Inc.
- United Technologies Corporation
- U.S. Paint Corporation

USEPA alleges that the following parties potentially own, previously owned and/or operated Site Q:

- Cahokia Trust Properties
- ConAgra, Inc. (leasee)
- Eagle Marine Industries Inc.
- Industrial Salvage & Disposal Company
- Peavey Company
- Phillips Pipe Line Company
- Pillsbury Company (leasee)
- Sauget & Company
- Union Electric Company
- Village of Cahokia
- Village of Sauget

1.2.4 Site R

Site R, a closed industrial-waste disposal area owned by Solutia Inc, is located between the flood control levee and the Mississippi River in Sauget, Illinois. It is approximately 24 acres in size (500 feet by 2,000 feet). Its northern border is Monsanto Avenue and its southern border is Site Q. A portion of Site Q, known as the "Dog Leg", is located to the east of Site R. This site was once called the "Sauget Toxic Dump" and the "Monsanto Landfill," however, it is now known as the "River's Edge Landfill".

Industrial Salvage and Disposal, Inc. (ISD) operated the River's Edge Landfill for Monsanto from 1957 to 1977. Hazardous and non-hazardous bulk liquid and solid chemical wastes and drummed chemical wastes from Monsanto's W.G. Krummrich plant and, to a lesser degree, its' Queeny plant in St. Louis were disposed at Site R. Disposal began in the northern portion of the site and expanded southward. Wastes contained phenols, aromatic nitro compounds, aromatic amines, aromatic nitro amines, chlorinated aromatic hydrocarbons, aromatic and aliphatic carboxylic acids and condensation products of these compounds.

In 1979, Monsanto completed the installation of a clay cover on Site R to cover waste, limit infiltration through the landfill, and prevent direct contact with fill material. The cover's thickness ranges from 2 feet to approximately 8 feet. In 1985, Monsanto installed a 2,250-foot long rock revetment along the east bank of the Mississippi River adjacent to Site R. The purpose of the stabilization project was to prevent further erosion of the riverbank and thereby minimize potential for the surficial release of waste material from the landfill. During the 1993 flood, Site R was flooded but the clay cap was not overtopped. No erosion of the riverbank or cap resulted from this flood.

Access to Site R is restricted by fencing and is monitored by Solutia plant personnel.

On February 13, 1992, the State of Illinois and Monsanto signed a consent decree entered in St. Clair County Circuit Court requiring further remedial investigations and feasibility studies to be conducted by Monsanto on Site R. The results of the RI/FS were submitted to IEPA in 1994. Solutia made a good faith offer to the IEPA to install an engineered cap and a leachate recovery system in 1997.

Parties who allegedly own, previously owned and/or operated Site R include:

- Cahokia Trust Properties
- Monsanto Company
- Solutia Inc.
- Sauget and Company

1.2.5 Site S

Site S is located southwest of Site O. It is approximately 0.92 acres in size (approximately 100 by 400 feet). Allegedly, the property is or was owned by the Village of Sauget, Clayton Chemical and/or the Resource Recovery Group. In the mid-1960s, solvent recovery began on the Clayton Chemical property, part of which is included in Site S, which is now owned by the Resource Recovery Group (RRG). The waste solvents were steam-stripped resulting in still bottoms that were allegedly disposed of in a shallow, on-site excavation that is now designated Site S. Historical aerial photographs indicate that Site S was potentially a waste and/or drum disposal area. The northern portion of the site is grassed and its southern portion is covered with gravel and fenced.

1.3 GEOLOGY, HYDROLOGY AND HYDROGEOLOGY

1.3.1 Geology

American Bottoms, the floodplain area on the east side of the Mississippi River, consists of unconsolidated valley fill deposits which are composed of recent alluvium (Cahokia Alluvium) unconformably overlying glacial material of the Henry Formation. These unconsolidated deposits are underlain by Pennsylvanian and Mississippian age limestone and dolomite with lesser amounts of sandstone and shale.

Cahokia Alluvium (recent deposits) consists of unconsolidated, poorly sorted, fine-grained materials with some local sand and clay lenses. Shallow Cahokia Alluvium is a fine-grained silty sand that becomes coarser with depth. These deposits are about 40-feet thick.

The underlying Henry Formation consists of approximately 40 feet of coarse-grained glacial outwash deposits composed of medium to coarse-grained sands that become coarser with depth. In some areas, till and/or boulder zones were found 10 to 15 feet above the base of this unit.

Previous subsurface investigations conducted at the site (Geraghty & Miller, Inc. Remedial Investigation at Sauget Site R, August 1994) have identified a fill layer which is approximately

5-to 20-feet thick overlying the Cahokia Alluvium which was observed to be approximately 50-feet thick. The Henry Formation was observed to be approximately 80-feet thick during these investigations.

1.3.2 Hydrology

One major surface-water feature, the Mississippi River, is found in the study area. Topographically, the area consists, primarily, of flat bottomland although many minor irregularities occur locally. Generally, land surface in the American Bottoms area slopes from north to south and from east to west toward the Mississippi River. Land surface elevation ranges from 400 to 410 feet above MSL with little topographic relief.

1.3.3 Hydrogeology

Site-specific geologic data show that the unconsolidated deposits range from 140-feet thick near the river to about 110 feet east of the study area. At most locations, the contact between Cahokia Alluvium and the Henry Formation cannot easily be distinguished. However, three distinct hydrogeologic units can be identified: 1) a Shallow Hydrogeologic Unit (SHU), 2) a Middle Hydrogeologic Unit (MHU) and 3) a Deep Hydrogeologic Unit (DHU). The 30-feet thick SHU includes the Cahokia Alluvium (recent deposits) and the uppermost portion of the Henry Formation. This unit is primarily an unconsolidated, fine-grained silty sand with low to moderate permeability. The 40-feet thick MHU is formed by the upper to middle, medium to coarse sand portions of the Henry Formation. It contains a higher permeability sand than found in the overlying SHU and these sands become coarser with depth. At the bottom of the aquifer is the 40-feet thick DHU, which includes the high permeability, coarse-grained deposits of the lower Henry Formation. The zone is estimated to be about 40-feet thick.

Literature searches and aquifer tests performed during the 1994 Geraghty & Miller Remedial Investigation indicate that the hydraulic conductivities of the SHU, MHU, and DHU are 9.5, 3,300, and 2,600 gpd/ft^2, respectively. In metric units, the SHU, MHU, and DHU have hydraulic conductivities of 4 x 10^{-4}, 1.6 x 10^{-1} and 1.2 x 10^{-1} cm/sec, respectively.

The study area is very flat and surface drainage is predominantly by infiltration rather than surface runoff. Depth to water beneath the study area varies based on seasonal fluctuations, proximity to the river and the elevation of the Mississippi River. In general, depth to water

varies from less than 10 feet to about 20 feet deep. Groundwater flow direction is generally from east to west with groundwater discharging to the Mississippi River.

1.4 GROUNDWATER USAGE IN THE SAUGET AREA 2 AREA

Groundwater is not used as a drinking water source in the Village of Sauget. In fact, groundwater use is controlled by village ordinance. No public water supply wells are located near the study area. The nearest water supply well listed in public records is located at the former Falcon Drive-In Theater in East St. Louis, greater than two miles to the north. No residential wells were identified at or near the study area. Potable water is supplied to area industry and residents by a public water supply system that obtains its water from a surface water intake in the Mississippi River upstream of SA2.

1.5 SURROUNDING LAND USE AND POPULATION

Heavy industry has located on the east bank of the Mississippi River between Cahokia and Alton, Illinois for nearly a century. Industrial activity peaked in the 1960s and industries have been closing ever since. Although heavy industry has shut down throughout the American Bottoms, the area around SA2 is still highly industrialized. In addition to heavy industry, the area currently has warehouses, trucking companies, and other commercial facilities. Industrial facilities currently operating in or near SA2 are listed below:

Facility	Use
• Cahokia Marine Services	Coal Bulk Storage and Transfer
• Eagle Marine Industries	Barge Terminal and Fleeting
• Phillips Petroleum	Petroleum Bulk Storage and Transfer
• Onyx Environmental Services	Hazardous Waste Treatment
• Peavey/ConAgra	Bulk Grain Storage and Transfer
• Resource Recovery Group	Waste Recycling
• River City Landscape and Supply	Lawn and Garden Product Storage
• Slay Terminals	Coal Bulk Storage and Transfer
• St. Louis Grain Company	Bulk Grain Storage and Transfer
• Union Electric	Electricity Distribution

The SA2 Site is transected by several petroleum or natural gas pipelines operated by Explorer Pipeline Company, Marathon, Phillips Pipeline and ExxonMobil.

Two dismantled industrial facilities, Midwest Rubber and Darling Fertilizer, were located east of the study area.

Two active wastewater treatment plants, the Physical/Chemical Wastewater Treatment Plant (PChem Plant) and the ABRTF, are located in the area. Both of these treatment plants are owned by the Village of Sauget. An operating hazardous waste incinerator, Onyx Environmental Services, is also located in the area. The RRG recycled wastes at the location where Clayton Chemical reprocessed waste solvents. Additional information about the historical activities at the RRG area are presented later in this section. No additional information concerning current activities at this facility is known to the PRP Group. The facility reportedly is not currently active, and USEPA is conducting an emergency response at this facility.

No residential land use is located adjacent to or in the immediate vicinity of the SA2. Residential areas of Sauget and East St. Louis are separated from the study area by other industries or undeveloped tracts of land. Limited residential areas exist to the northeast and southeast of these industrial facilities. Industrial areas exist approximately 2,000 feet west of the study area, across the Mississippi River in the City of St. Louis, Missouri, with residential areas further to the west.

A number of industrial facilities are or were located hydraulically upgradient of SA2 Sites including:

Facility	Activity
• Astaris	Phosphorous Pentasulfide Manufacturing
• Big River Zinc	Zinc Refining
• Cerro Copper	Copper Tube Manufacturing
• Ethyl Petroleum Additives, Inc.	Petroleum Additive Manufacturing
• Flexsys	Rubber Chemicals Manufacturing
• Oxychem	Swimming Pool Chlorine Manufacturing
• Solutia	Monochlorobenzene Manufacturing
• Sterling Steel Castings	Foundry

American Bottoms Regional Treatment Facility – The Village of Sauget, Illinois owns and operates the ABRTF. The ABRTF brought on line in 1986 provides both primary and secondary treatment for its regional service area. It also provides secondary treatment for effluent from the PChem Plant. The PChem Plant provides primary treatment for village wastewater that consists

primarily of industrial wastewater. ABRTF has an National Pollutant Discharge Elimination System (NPDES) Permit (No. IL0065145) to discharge treated effluent via a multi-port diffuser to the Mississippi River at river mile 178. American Bottoms provides primary treatment as well as secondary biological treatment enhanced by powdered activated carbon.

Darling Fertilizer - Darling manufactured chemical fertilizers from 1922 to 1967. This process involved acidulation of phosphate rock and the subsequent blending of the rock with nitrates, lime, etc. After operations ceased, the plant was dismantled.

Midwest Rubber – Midwest Rubber began operations in 1928. The company reclaimed rubber, principally from discarded automobile tires by heating the tires in autoclaves with caustic solution or chloride solution. Scrap rubber was run through a series of grinding processes creating sand-size granules that were fed into a dynamic devulcanizer unit and heated along with pitch, aromatic disulfide and turpene additives. This process produced a soft grade of rubber that was milled, compressed into blocks and sold for reuse in less expensive rubber products such as mats and toy tires. Butyl rubber was also manufactured at the site. A release of diptene and gasoline from an underground storage tank at the facility was reported in January 1990. The plant is now dismantled. Aboveground storage tanks were removed in 1997 and underground storage tanks were removed in 1998.

Phillips Petroleum - Phillips Pipeline Company, a subsidiary of Phillips Petroleum, operates an active terminal for bulk storage and transfer of petroleum and propane at 3300 Mississippi Avenue in the Village of Cahokia. This facility, in operation since 1931, currently has 58 aboveground petroleum storage tanks with a total capacity of 2,309,235 barrels (96,987,970 gallons). It also has two aboveground propane storage tanks. Unleaded gasoline, premium unleaded gasoline, No. 2 low-sulfur distillate, No. 2 high-sulfur distillate, overhead gasoline, 100 aviation fuel, K-1, butane, propane, oil mix, sulfur distillate and ethanol are stored in these tanks. The terminal receives product via pipeline, rail tankers and trailer trucks. Products are moved from the terminal via tank trucks and pipelines.

Resource Recovery Group - This 7.35-acre property, and the area around it, was used as a railroad repair yard, complete with roundhouse and terminal, from 1930 to 1962. In 1962, Joseph Reidy began operating a crude oil topping plant at the site. Products derived from this operation included white gas, distillate fuel oils and residual bottoms materials. Oil tank bottoms

and white gas were disposed to the ground on site. Clayton Chemicals began solvent reclamation in the mid-1960s and continued until 1978. In 1983, IEPA modified the site's permit to allow acceptance and distillation of the following spent solvents:

- Spent halogenated-solvents including; Tetrachloroethylene; Trichloroethylene; 1,1,1-Trichloroethane and Methylene Chloride
- Spent nonhalogenated-solvents including; Xylene, Acetone, Ethyl Acetate, Toluene and Methyl Ethyl Ketone
- Spent high flash-point, nonhalogenated-solvents including; Mineral Spirits, Glycol Ether and heavy Naptha.

All spent solvents were to have a minimum solvent content of 30%. (F001), (F002), (F003) and (F005) and other sludges and still bottoms were excluded. Clayton Chemical was sold to Emerald Environmental in December 1993 and later renamed the Resource Recovery Group.

Trade Waste Incineration - Trade Waste Incineration (TWI) began operating a hazardous waste incinerator on the Clayton Chemical property in 1980. Operations were relocated to their current site in 1983 after the property was purchased from the Illinois Central Gulf Railroad. In or about 1982, TWI connected its scrubber drain to the village sewer system so that blowdown could be treated at the Publicly Owned Treatment Works (POTW). Scrubber sludge was drawn off and added to the waste ash removed from the incinerator. The incinerator operations are now owned by Onyx Environmental Services, LLC.

1.6 SENSITIVE ECOSYSTEMS

The SA2 Sites are within the wintering habitat range of the Bald Eagle, which has Federal "Endangered Species" protection. Bald Eagles were observed at Sites Q and R by USEPA and IEPA personnel in 1999. In addition, the site is within the range of the Federal "Threatened Status" decurrent false aster (Boltonia Decurrens).

1.7 METEOROLOGY AND CLIMATOLOGY

Climate at the site is continental with hot humid summers and mild winters. Periods of extreme cold are short. Average annual rainfall from 1903 to 1983 was 35.4 inches and from 1963 to

1988 it was 39.5 inches. Average annual temperature is 56°F with the highest average monthly temperature in July (79°F) and the lowest average temperature in January (32°F).

1.8 PREVIOUS SUBMITTALS

The RI was performed at the SA2 Sites O, P, Q, R, and S from June 2002 through October 2002. Preliminary screening activities in Site Q were performed in November 2001 and quarterly groundwater sampling was conducted following completion of field activities in October 2002. The field activities were conducted in accordance with the SSP. Following the completion of the RI activities, the SA2SG submitted several interim reports to USEPA and IEPA. These submittals were intended to provide an on-going transmittal of data and pertinent information. These submittals are:

- Support Sampling Data Report - April 1, 2003 - This report included all the data on a constituent-by-constituent basis (URS, 2003a)
- Data Validation Report - May 1, 2003 - This report included a summary of the data validation process and the resulting validated data including the data for samples collected in 2002 (URS, 2003b)
- Field Sampling Report - June 25, 2003 - This report included a summary of field and sample collection procedures (URS, 2003c) (FSP).
- Field Sampling Report of Aquatic Sampling Activities – June 5, 2003 – This report included a summary of field and sample collection procedures for aquatic samples use in the BERA (AMEC, 2003a).
- Floodplain Area Field Sampling Report – June 10, 2003 – This report included a summary of field and sample collection procedures for floodplain samples used in the BERA (AMEC, 2003b).
- Human Health Risk Assessment - August 31, 2003 - This report included an evaluation of human health risks based on the analytical data (ENSR, 2003) (HHRA).
- Baseline Ecological Risk Assessment - August 2003 -This report included an evaluation of ecological risks based on the analytical data (AMEC, 2003c) (BERA).

SECTION TWO Previous Removal/Remedial Actions

2.1 PREVIOUS REMOVAL AND REMEDIAL ACTIONS

2.1.1 Site O

In 1980, the Village of Sauget closed four clarifier sludge lagoons at Site O by stabilizing sludge with lime and covering it with approximately 2 feet of clean, low-permeability. Currently, the lagoons are vegetated.

2.1.2 Site Q

USEPA initiated a removal action at Site Q on October 18, 1999. The Emergency and Rapid Response Services (ERRS) contractor began to excavate site wastes on October 26, 1999 from eight excavation areas of various sizes on approximately 25-acres of site property. Two waste streams were developed based upon analytical results of the separate waste piles: 1) a low-level PCB waste stream with soil concentrations less than 50 ppm that was shipped via truck to the Milam Recycling and Disposal Facility (Milam) located in East St. Louis, Illinois and 2) a PCB waste stream with soil/debris containing greater than 50 ppm PCBs that was shipped via rail car to the Safety-Kleen Lone & Grassy Mountain (Lone Mountain) facility, located in Waynoka, Oklahoma. One hundred sixty three trucks, each containing approximately 20 tons of low-level PCB waste, were shipped to the Milam disposal facility. One hundred forty one rail cars, each containing approximately 90 tons of PCB waste, were shipped to the Lone Mountain facility. Drums excavated on-site were crushed and added to either waste stream. Excavated drums that were void of waste material were added to either PCB waste stream; drums that contained waste were added to the greater 50 ppm PCB waste stream.

On April 5, 2000, removal of site wastes was completed. Approximately 17,032 tons of waste and 3,271 drums were removed from the site. Due to limited resources and the amount of contamination, this removal action did not address all of the contaminants present on the site. As a result, municipal waste is visible on limited portions of the site.

2.1.3 Site R

In 1979, Monsanto completed the installation of a clay cover on Site R to cover waste, limit infiltration through the landfill, and prevent direct contact with fill material. The cover's thickness ranges from 2 feet to approximately 8 feet. In 1985, Monsanto installed a 2,250-foot long rock revetment along the east bank of the Mississippi River adjacent to Site R. The purpose of the stabilization project was to prevent further erosion of the riverbank and thereby minimize

potential for the release of waste material from the landfill. During the 1993 flood, Site R was flooded but the clay cap was not overtopped. No erosion of the riverbank or cap resulted from this flood.

On February 13, 1992, the State of Illinois and Monsanto signed a consent decree entered in St. Clair County Circuit Court requiring further remedial investigations and feasibility studies to be conducted by Monsanto on Site R. The results of the RI/FS were submitted to IEPA in 1994. Solutia made a good faith offer to the IEPA to install an engineered cap and a leachate recovery system in 1997.

USEPA issued a Unilateral Administrative Order (V-W-'02-C-716) for Remedial Design and Interim Remedial Action on October 3, 2002 for a Remedial Design/Remedial Action for the SA2 Groundwater Operable Unit (OU-2), which encompassed the groundwater contamination releasing to the Mississippi River adjacent to Site R and the resulting impact area in the river. On September 30, 2002, USEPA selected an interim groundwater remedy for this OU consisting of a 3,500-feet long, 140-feet deep, "U"-shaped, fully-penetrating barrier wall installed between the downgradient boundary of SA2 Site R and the Mississippi River and three-partially penetrating groundwater recovery wells inside the barrier. Implementation of this remedy will abate the release of impacted groundwater to the Mississippi River and control groundwater moving into the barrier wall. In response to this Order, which became effective on November 15, 2002, Solutia submitted a Remedial Design/Remedial Action Work Plan for the Sauget Area 2 Groundwater Migration Control System (URS, 2002a) on December 29, 2002 a Pre-Final Design on January 21, 2003 and a Final Design on July 3, 2003 (URS, 2003d). USEPA issued "Conditional Approval of the Groundwater Extraction System Design" on May 15, 2003. Construction of the extraction wells, discharge piping and control system was completed and the groundwater extraction system was started on July 15, 2003. Discharge rates were initially limited by the ABRTF to ensure successful acclimatization of the biological wastewater treatment system, however, full discharge to the ABRTF started on October 22, 2003. USEPA approved the Final Design for the Sauget Area 2 Interim Groundwater Remedy (SA2IGR) on October 16, 2003. In anticipation of design approval, equipment for installation of the barrier wall was mobilized to the Site R on August 18, 2003, pre-trenching for the slurry wall began on

August 29, 2003 and slurry trench excavation began on September 4, 2003. As of November 7, 2003, approximately 650 feet of slurry trench was excavated to bedrock, which was encountered at a depth of approximately 135 feet. Current plans call for completing installation of the barrier wall in the first quarter of 2004.

SECTIONTHREE Remedial Investigation

This section summarizes the field activities for the RI that was performed at the SA2 Sites O, P, Q, R, and S for the SA2SG. The field activities were conducted in accordance with the RI/FS SSP dated April 15, 2002.

3.1 AERIAL PHOTO ANALYSIS

Historical aerial photographs were obtained for years ranging from 1955 to 2000 for the Sauget and Cahokia, Illinois areas, which included Sites O, P, Q, R, and S. These photographs were used to verify the extent of excavation and fill activities, which were previously identified in the FSP, April 15, 2002. Stereoscopic photo pairs were analyzed for each year, and the apparent fill areas were sketched on a composite figure showing the extent of fill areas over time for each site. Following the photo analysis, a boundary line was drawn around the outside of the composite fill areas for each site. Stereoscopic evaluation of historical aerial photographs was used in an attempt to identify the deepest portions of the fill areas.

The results of the aerial photo evaluation indicated that the boundaries for Sites P, Q, R, and S were accurate, however, three additional areas were identified outside of the previously drawn boundaries for Site O. These included an area adjacent to the northern boundary, which appeared as pits associated with the operation of the PChem plant, an area adjacent to the southern boundary, which appeared to be associated with a breach in the dyke of the lagoon, and an area adjacent to the western boundary, which appeared to contain ponded water. Each of these areas was investigated further through the use of test trenches and soil gas surveys. The site boundaries are shown on Figure 3-1.

3.2 DISPOSAL AREAS IDENTIFICATION

3.2.1 Magnetometer Survey

Magnetometer surveys were conducted at four of the five sites (P, Q, R, and S) to identify magnetic anomalies in the subsurface. No magnetometer survey was conducted at Site O since site closure records indicated that there were no drums present. Magnetometer measurements were collected at the center points of a 50 by 50 foot grid superimposed on each of the disposal areas. The established survey lines were marked in the field using a premarked survey line to maintain straight and precise station locations. Profiles were completed along a straight line with an unobstructed line of sight, and each measurement location was marked with a surveyors flag.

The corners of each of the gridded areas were marked with temporary corner stakes to permit the relocation of the measurement points within each site.

The geophysical survey of the site's magnetic field was completed utilizing a Ferex gradeometer magnetometer. Field procedures and operation of the instruments were in accordance with the recommended manufacturer's field procedure and application manual.

The field magnetometer measured the strength of the site's magnetic field regardless of the orientation of the magnetic lines of force. During the performance of the geophysical survey, data were collected that resulted in contour maps depicting the distribution of magnetic field strength over the site. These maps were compared with the observed field conditions (including the location of known interfering objects such as vehicles, overhead power lines, and surface debris). By comparison, those magnetic anomalies which could not be explained by observed site conditions were presumed to be a result of buried subsurface material (e.g., drums, tanks, metal debris, etc.).

3.2.2 Soil Gas Survey

A soil gas survey was performed at each of the five sites to assist in verifying the boundaries of the disposal areas. Soil gas samples were collected at the center points of a 200 by 200-foot grid, superimposed on each disposal area.

Direct-push technology was used to advance a retractable point holder to 5.5 feet below existing grade. The rods were then pulled back 6 inches to approximately 5 feet below existing grade to disengage the retractable point, therefore, exposing the sampling mechanism. Polyethylene tubing (0.125-inch diameter) was then lowered into the rods. The upper end of the polyethylene tubing was connected to a 4-inch section of silicone tubing, which was then attached to a section of polyethylene tubing coming from an active vacuum system and a vacuum was placed on the tubing. A 60cc sample of soil gas was withdrawn from the silicone tubing using a 60cc disposable syringe with a stainless steel needle. The sample was then directly injected into the on-site GC. The GC provided a report of the total VOC concentrations.

Following sample collection, sample tubing was removed from the probe and disposed. Probing rods and sampling equipment were removed from the boring and the boring was filled with bentonite to just below existing grade. The bentonite was then hydrated with potable water and the surface was restored to its original condition.

If detectable concentrations of total VOCs were found in the soil gas samples from borings located along a site boundary, then additional borings were advanced along a transect perpendicular to that site boundary. Borings were advanced every 100 feet along the transect until VOC concentrations fell below the on-site laboratory reporting limits. If no VOCs were detected along a site boundary, no additional borings were advanced.

A total of 339 of the 348 originally proposed soil gas borings were advanced at the five sites. In addition, soil gas samples were collected at 15 step-out locations. A summary of the number of soil gas sample locations for each site is provided in Table 3-1. The elimination of nine of the originally proposed soil gas sample locations, which could not be collected due to utility hazards, high water table, or unattainable access, was approved in the field by the USEPA Region V representative (CH2MHill) and were recorded on a Field Clarification Log. Photographic documentation of the soil gas sampling activities is provided in Appendix A. Locations of soil gas survey locations are presented in Figures 3-3a through 3-3c.

3.2.3 Test Trenches

3.2.3.1 Boundary Trenches

Test trenches were used to confirm the boundaries of the waste disposal areas identified through the aerial photo and soil gas analyses. One trench was installed on each side of a waste disposal area. Thus, there were a total of four trenches in each of Sites O, P, R, and S. Because of the larger total area and varying types of disposal activities in Site Q, eight boundary trenches were used to assess the site. The trenches were positioned to assess the features identified on the aerial photos, and each location was selected in the field with the concurrence of the USEPA Region V representative (CH2MHill). A global positioning system (GPS) was used to document the locations on aerial site maps and to locate the position in the field. Locations of test trenches for boundary confirmation are shown on Figures 3-4a through 3-4e.

All trenching activities were conducted in a manner to protect existing utilities, structures, surface features, monitoring wells, and the general site environment. Additionally, trenching activities followed Occupational Safety and Health Administration (OSHA) rules for excavations. A "competent" person, as defined in 29 CFR 1926.650, observed the trenching activities and had authorization to take corrective measures to respond to unsanitary, hazardous,

or dangerous conditions to workers. A track-mounted excavator with an extended arm was used for excavation.

Each trench began outside of an assumed disposal area boundary and moved in towards the boundary until waste materials were encountered. If waste materials were encountered initially, the trenching activities proceeded out and away from the boundary until native soils were encountered. The trenching extended vertically to a maximum depth of 40-feet bgs or to groundwater, whichever was encountered first, and horizontally to a maximum length of 40 feet. Some trenches were terminated before reaching 40-feet bgs due to cave-in conditions in the trench. In order to minimize the generation of investigation-derived wastes, no accommodations were made to dewater test trenches or manage groundwater during excavation activities. The definition of waste was addressed in a field clarification log approved by the USEPA Region V representative (CH2MHill). During field activities, waste was defined as any municipal waste material, drum remnant, debris consistent with landfill material, fully saturated soils containing free product, and/or material not consistent with fill material. Partially saturated soils or discolored soils not fully saturated with free product were not considered waste unless mixed with material defined as waste previously.

The location where no additional waste materials were encountered within the test trench was designated as the extent of the site boundary for that location and compared to the location identified in the air photo analysis. Trenching at that location was then terminated. Table 3-2 presents a summary of boundary trench data. Photographic documentation of trenching activities is provided in Appendix A.

As the trenching proceeded, the top 1-foot of spoils material was placed directly on the ground to facilitate material placement at the completion of the trench. The remaining spoils were placed on polyethylene plastic, which had a minimum thickness of 6 millimeters. Provisions were made to allow free liquids in the spoils to drain back to the trench, if necessary. Spoils from each test trench were segregated and returned to the excavation in reverse order of removal. The gross contamination was removed from the excavator bucket with a shovel, brush, and/or potable water source prior to handling the cover material. Decontamination debris was placed into the excavation trench prior to placement of cover material. Investigation-derived wastes (IDW) from these activities, such as polyethylene plastic, were placed in 55-gallon drums and stored on-site at the IDW pad.

Backfilling was conducted in a manner which minimized ponding of water over the trench. If necessary a silt fence was installed around the perimeter of the trench to minimize runoff of surface soils during rain events. A test trench at one location was backfilled prior to the initiation of a test trench at another location. After completion of site investigation activities, the sites were allowed to revegetate naturally.

3.2.3.2 Anomaly Trenches

A total of 11 anomaly trenches were installed to investigate the potential presence of buried drums or tanks as identified during the magnetometer survey. One anomaly trench was installed in each of the Sites P, R and S and eight anomaly trenches were installed in Site Q. No anomaly trenches were performed at Site O since site closure records indicated that there were no drums present. In an effort to reduce the potential risks to the community, on-site workers and the environment, each magnetic anomaly was evaluated against four criteria:

1. A soil gas concentration high
2. Drum or tank disposal locations identified by historical air photo interpretation
3. An area of high groundwater concentrations (greater than 10,000 parts per billion (ppb)) as identified by the 1998 Ecology and Environment Data Report
4. Major magnetic anomalies reported in the 1988 Ecology and Environment Report, "Expanded Site Investigation, Dead Creek Project Sites at Cahokia/Sauget, Illinois."

An anomaly trench was installed at the most appropriate magnetic anomaly; however, care was taken not to place major emphasis on the comparison of historical groundwater concentrations and magnetic anomalies due to the extent of historical industrial groundwater pumping in the area. Anomaly test trench locations were selected in the field with the concurrence of CH2MHill. A GPS system was used to document the locations on aerial site maps and locate the position in the field. Locations of anomaly trenches are shown on Figures 3-4a through 3-4e.

Trenching activities were conducted in a manner to protect existing utilities, structures, surface features, monitoring wells, and the general site environment. Additionally, trenching followed OSHA rules for excavations. To complete the anomaly test trench, a track-mounted hoe was utilized.

Anomaly test trenches were advanced until evidence of buried drums or tanks was encountered or to a maximum length and depth of 40 feet. If groundwater infiltration and/or poor soil stability resulted in the inability to complete a test trench to 40-feet bgs, the trenching was terminated at that location. Infiltrating groundwater was not managed during excavation activities. Table 3-2 presents a summary of anomaly trench data. Photographic documentation of trenching activities is provided in Appendix A.

As the trenching proceeded, the top 1-foot of spoils material was placed directly on the ground to facilitate material placement at the completion of the trench. The remaining spoils were placed on polyethylene plastic, which had a minimum thickness of 6 millimeters. Provisions were made to allow free liquids in the spoils to drain back to the trench. Spoils from each test trench were segregated and returned to the excavation in reverse order of removal. The gross contamination was removed from the excavator bucket with a shovel, brush, and/or potable water source prior to handling the cover material. Decontamination debris was placed into the excavation trench prior to placement of cover material. Investigation-derived wastes from these activities, such as polyethylene plastic, were placed in 55-gallon drums and stored on-site at the IDW pad.

Backfilling was conducted in a manner which minimized ponding of water over the trench. If necessary a silt fence was installed around the perimeter of the trench to minimize runoff of surface soils during rain events. A test trench at one location was backfilled prior to the initiation of a test trench at another location. After completion of site investigation activities, the sites were allowed to revegetate naturally.

3.3 WASTE CHARACTERIZATION

3.3.1 Waste Samples

A total of 25 waste borings were advanced using both direct push and sonic drilling technologies. The waste boring locations were selected based on the 1998 Ecology and Environment Report, the results of the aerial photograph analysis, and the soil gas and magnetometer surveys conducted as a part of this field effort. These locations were designed to characterize the waste materials present at each disposal site.

The three waste borings in Site O, two borings in Site S, and four borings in Site R were advanced using direct push technology (Geoprobe®). A decontaminated, acetate lined, stainless steel, macro-core sampling tube (2-inch diameter by 4-feet long) was hydraulically driven into

the ground at the sampling locations. The tube was retrieved to the surface and the soil samples removed from the disposable acetate liner within the tube. Continuous samples were collected from grade to 2 feet below the bottom of the waste material, which was between 5 and 30 feet below grade.

In Sites P and Q, the Geoprobe® was unable to advance the sampler to the desired depths due to the presence of a substantial amount of rubble. Therefore, the four waste borings in Site P and the twelve waste borings in Site Q were advanced using sonic drilling technology. Sonic drilling technology utilizes sonic resonation to loosen the cohesion of the formation immediately surrounding and below the casing (area of influence is approximately 1/16-inch), which is simultaneously being hydraulically pushed. Continuous soil samples were collected using a 4-inch diameter core barrel and a 6-inch override casing. The core barrel was advanced to collect an undisturbed core sample and then the override casing was advanced to the same depth as the core barrel to eliminate cave-ins or formation mixing. Once the override casing was advanced, the soil sample was pulled out of the borehole and then the boring continued.

During the advancement of all the waste borings, the subsurface stratigraphy was logged by a qualified field scientist in accordance with the Unified Soil Classification System (USCS) and standards outlined in Appendix J of the FSP. The field scientist noted soil attributes such as color, particle size, consistency, moisture content, structure, plasticity, odor (if obvious) and organic content (if visible). Waste samples from each boring were screened in the field using a PID and visually evaluated for evidence of impact to determine if waste materials were present. These observations were noted on Field Boring Logs. Boring Logs are presented in Appendix B.

If waste was present in a sample, it was removed, segregated, temporarily stored, and used at the completion of the waste boring to prepare a composite waste sample. The composite waste sample was collected and analyzed for SVOCs, pesticides, herbicides, PCBs, and metals. In addition, a portion of the composite waste sample from above the water table was extracted using TCLP procedures. The TCLP extraction was performed to obtain an aqueous solution, which was analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, and metals. The results of these samples in which TCLP extraction was performed will be referred to as "TCLP extract" throughout this document. Standard TCLP analyses were performed separately and used later to determine if characteristically hazardous waste are present. Since VOC samples cannot be composited without losing volatiles, the waste sample interval with the highest PID reading was

collected for standard VOC and dioxins analysis. In addition, a sample was collected from this interval and analyzed for VOCs and dioxins following the TCLP extract procedures defined previously. After completion of the waste boring and sample collection the remaining waste from each boring was placed in a 5-gallon bucket and stored on-site for future treatability testing.

The waste samples were transferred to laboratory-supplied containers for shipping and analysis. Samples for VOC analysis were collected using a 5-gram Encore® sampler. Each sample container was labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each label was sealed with clear polyethylene tape and the samples were logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C.

The waste samples along with the corresponding chain-of-custody form were shipped via an overnight delivery service to Seven Trent Laboratories in Savannah, Georgia for analysis of VOCs, SVOCs, pesticides, herbicides, PCBs, and metals, and to Severn Trent Laboratories in Sacramento, California for analysis of dioxins.

After sampling was completed, each waste boring was filled with a bentonite slurry or hydrated bentonite chips, and the surface was returned to its original condition. Excess soil and waste cuttings and acetate liners were placed in 55-gallon drums that were labeled, sealed, and staged on-site. Sampling equipment (core barrel, override casing, drill rig) was decontaminated between borings using a steam pressure washer.

Tables 3-3 and 3-4 presents a summary of each boring and the waste samples collected. The locations of waste samples are presented on Figures 3-5a through 3-5e. Photographic documentation of drilling activities and the waste samples is provided in Appendix A.

3.3.2 Leachate Wells

3.3.2.1 Installation

Seven leachate monitoring wells were installed using sonic drilling technology. The location, depth and screened interval of each well were determined based on stratigraphic information gathered during the waste sampling activities. One leachate well was installed at the waste boring location within each site (three were installed in Site Q), which had the greatest

indications of potential impact (visual, olfactory, or PID) or the greatest depth of waste materials. The locations of leachate wells are provided on Figure 3-6a through 3-6e.

Leachate well borings were completed by continuously advancing a 4-inch core barrel and 6-inch override casing through the waste materials to the surface of the underlying native soil. The waste thickness observed in each leachate monitoring well location was assumed to be similar to the waste thickness at the corresponding waste boring. The 6-inch override casing was temporarily left at the surface of the native soil to serve as an isolation casing, preventing movement of contaminants within the waste material into the underlying native soil. The seal was formed by the sonic resonation of the 6-inch override casing as it was advanced. This sonic resonation energized the waste and soil material surrounding the casing and when the resonation stopped, the energized waste material sealed back around the casing providing a tight seal and preventing the migration of groundwater downward along the casing wall. Waste material was continuously inspected and logged. Information pertaining to the subsurface waste materials and drilling conditions was recorded in the field on a standard Field Boring Log form. Boring Logs are provided in Appendix B.

If the total depth of the boring extended beyond the desired monitoring well installation depth (typically the base of the waste), the borehole was backfilled with hydrated bentonite chips to a depth of 0.5 to 1 foot beneath the base of the well screen. This bentonite seal prevented the downward migration of leachate into the underlying native soil. A 0.5 to 1-foot thick silica filter sand buffer layer was placed above the bentonite backfill and beneath the well base to prevent the bentonite backfill from expanding into the well screen after hydration.

Monitoring wells were constructed of Schedule 40 PVC riser pipe, and screens were installed at the base of the fill material. The well screens ranged between 2.5 and 10-feet in length with 0.010-inch slots. A sand filter pack consisting of 20/40 sieve size silica sand was installed from the bottom of the well to a distance of 0.5 to 2 feet above the top of the screen. The remaining annular space above the silica sand filter pack to a distance of 1.5 to 3 feet bgs was filled with hydrated bentonite chips. All well construction materials were placed through the 6-inch override casing. The override casing was extracted from the borehole at an equivalent rate to that of the filter sand and bentonite being introduced into the annular space of the well. In addition, the override casing was resonated during its removal to assist in the formation of an effective seal between the bentonite and surrounding subsurface materials. The upper 1.5 to 3

feet of annular space was filled with concrete. Variations in the height of the sand pack above the well-screen, thickness of the bentonite chip seal, and depth of concrete were a result of variations in the total depth of each leachate well. Wellheads were finished as above-ground completions (except for Leach-Q-1 and Leach-Q-2). Keyed-alike locks were then placed on each well for security purposes. Well construction diagrams for the leachate monitoring wells are provided in Appendix C and completion depths of each monitoring well are summarized in Table 3-5.

3.3.2.2 Development

The objective of well development was to remove fines from the leachate well screen and filter pack so that representative groundwater samples could be collected. Generalized procedures stated in Appendix J of the FSP were followed during leachate well development.

The water elevation in each leachate well was measured from the top of casing (TOC) to the nearest $1/100^{th}$ of a foot using a petroleum/water interface probe. The total depth of the well from the TOC was also measured at this time. Water level measurements, the total well depth, and the screened intervals for each leachate-monitoring well are summarized in Table 3-5. These measurements were used to calculate the well volume of water for each monitoring well.

During gauging of the leachate wells, it was determined that leachate wells Leach-O-1, Leach-P-1, Leach-Q-2, and Leach-Q-3 were dry, and therefore, development was not able to be performed. Development of leachate monitoring wells Leach-O-1, Leach-Q-1, and Leach-R-1 was accomplished by lowering a dedicated, disposable polyethylene bailer into the well and placing it approximately 2.5 feet above the bottom of the well (near the middle of the well-screen). The bailer was raised and lowered across the screened interval to agitate the water and suspend the sediments in the well so that they could be removed. Water was then removed from the well using the bailer and discharged directly into Department of Transportation (DOT) approved 55-gallon drums, which were labeled with the well identification number, site location, date and contents. Development continued until a minimum of five well volumes of water had been removed from the well and the pH, conductivity, and temperature had stabilized. Readings were collected after each well volume of water had been removed and considered stabilized when two consecutive measurements were within the following criteria:

- ± 0.25 units for pH
- ± 10% for specific conductivity
- ± 1°C for temperature.

Leachate monitoring wells that purged dry during development were purged dry three times. The water was allowed to recharge to static conditions between each cycle of purging. If the well did not recharge to static conditions within 24 hours, the well was considered dry and development was complete. Groundwater sampling form presenting information relating to the development and sampling of each well are provided in Appendix D

Photographic documentation of the installation, development, and sampling of the leachate wells is provided in Appendix A.

3.3.2.3 Sampling

Prior to sampling, the water level in each well was measured from the TOC to the nearest 1/100th of a foot using a petroleum/water interface probe and this information was recorded. During the first sampling event in September 2002, four of the seven leachate wells were dry at the time of gauging and could not be sampled. During the January, April, and June 2003 sampling events, five of the seven leachate wells were dry at the time of gauging and could not be sampled. Water elevations collected from leachate wells are summarized in Table 3-5.

Leachate wells were sampled in September 2002, January, April, and June 2003 according to generalized procedures outlined in Appendices H and I of the FSP. The purpose of these samples was to characterize leachate at each site. Groundwater samples collected from leachate monitoring wells were analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals.

Sampling of the leachate wells was accomplished by the following procedures. A peristaltic pump equipped with the proper length of discharge tubing was lowered into the well and placed approximately 2.5 feet above the bottom of the well (near the middle of the well-screen). The pump was turned on and the flow adjusted to a maximum flow rate of 1 L/min. The flow rate was checked periodically to ensure a constant low-flow rate was maintained. Water was discharged into a graduated pail and then transferred to DOT approved 55-gallon drums, which were labeled with the well identification number, site location, date and contents. Purging continued until a minimum of three well volumes of water had been removed from the well and

the pH, conductivity, and temperature had stabilized or until the well was purged dry, whichever occurred first. Readings were collected after each well volume of water had been removed and considered stabilized when two consecutive measurements were within the following criteria:

- ± 0.25 units for pH
- ± 10% for specific conductivity
- ± 1°C for temperature.

In addition to the pH, specific conductivity, and temperature, other parameters including turbidity, dissolved oxygen (DO), oxygen reduction potential (ORP) were measured and recorded.

After purging was complete, groundwater samples were collected using a peristaltic pump with a flow rate of 1 L/min or less and/or a dedicated disposable polyethylene bailer. Samples were discharged directly into laboratory supplied sample containers. To minimize volatilization; samples obtained for VOC analysis were filled first using bottom discharge VOC samplers. Each sample container was labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each label was sealed with clear polyethylene tape and the samples were logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C.

The groundwater samples along with the corresponding chain-of-custody form were shipped via an overnight delivery service to Seven Trent Laboratories in Savannah, Georgia for analysis of VOCs, SVOCs, pesticides, herbicides, PCBs, metals, and several geochemical parameters, and to Severn Trent Laboratories in Sacramento, California for analysis of dioxins.

Photographic documentation of the installation, development, and sampling of the leachate wells is provided in Appendix A.

3.4 HYDROGEOLOGY

3.4.1 Alluvial Aquifers

Groundwater samples were collected from temporary borings in the alluvial aquifer, both downgradient and upgradient of the waste disposal areas. The purpose of this sampling was to

define the extent of migration away from the source area and to provide information for the HHRA.

Groundwater samples were collected at a total of 22 sample locations. Sites O, P, and S each contained three sample locations evenly spaced between the downgradient boundary of each site and the nearest downgradient site (Site O and S) or the Mississippi River (Site P) along east/west trending transects. Samples were collected at eight sample locations along the west property boundary of Site Q. Five of these locations were immediately adjacent to the Mississippi River in the central section of Site Q, and the three remaining locations were parallel to the river in the southern portion of Site Q. Samples were collected at one sampling location on the west property boundary of Site R. The locations of all downgradient sampling locations are presented on Figures 3-7a through 3-7e.

In addition to the downgradient sampling locations, groundwater samples were collected at four upgradient locations to the east of the SA2 Sites. One sampling location was upgradient and east of Site P, two sampling locations were located upgradient and east of the central section of the project area, including Sites O, S, R, and the northern portion of Site Q. The fourth sampling location was located upgradient and east of the southern portion of Site Q. The locations of all upgradient-sampling locations are presented on Figure 3-7f.

Groundwater samples were collected at 10 foot increments from the top of the water table to the bottom of the aquifer using the hydraulic push system of a Geoprobe® to advance a 4-foot stainless steel sampler with a wire wrap (slot size of 0.004 inches) to the desired sample depth. A peristaltic pump with dedicated polyethylene tubing was used to purge and sample at each interval. The polyethylene tubing was placed down into the slotted portion of the sampler and a discreet groundwater sample was collected from the desired interval. If the groundwater elevation fell below approximately 30 feet bgs, the peristaltic pump was not able to continue pulling the groundwater to ground surface. If this occurred, a ball and check valve system was used in conjunction with the peristaltic pump to manually purge and sample the groundwater. Initially, purging continued until:

- A minimum of three well volumes were purged at a maximum flow rate of 1 L/min
- pH, conductivity, and temperature readings had stabilized to within 10% over two consecutive well volumes

- The turbidity reading was at or below five nephelometric turbidity units (NTUs) unless that was unattainable, then until the turbidity reading is within 10% for two consecutive well volumes, or the well was pumped dry.

If after two hours of purging, the turbidity level was still above five NTUs and had not stabilized to within 10% over two consecutive well volumes, purging was deemed complete and the groundwater sample was collected.

On July 12, 2002, Mike Ribordy of the USEPA Region V signed a field clarification log, which outlined that purging would be continued until:

- pH, conductivity, and temperature readings, collected at a minimum of every ten minutes, had stabilized to within 10% over two consecutive readings
- At least three well volumes of groundwater were removed or one hour of purge time had elapsed and at least 1.5 well volumes of water had been purged.

Along with pH, conductivity, and temperature readings, field parameters recorded using a flow-through cell during purging included turbidity, DO and ORP.

After sample collection was complete at the desired depth, the sampler was advanced to the next desired sample depth by connecting clean sections of push rods to the Geoprobe®. This process was continued until all samples were collected. New polyethylene tubing was used for each sample depth. Each alluvial aquifer boring was sampled from the water table to the bottom of the aquifer. Each sample was analyzed for VOCs and SVOCs. Additionally, unfiltered samples were collected at the top and bottom of the aquifer and at 40-foot intervals and analyzed for pesticides, herbicides, PCBs, metals, and several geochemical parameters (presented in Tables 3-6a through 3-6f).

In addition, samples were collected for dioxins analysis at the following sampling locations:

- The sampling location closest to Site O (AA-O-1)
- The sampling location closest to Site P (AA-P-1)
- At two sampling locations in Site Q (AA-Q-2 and AA-Q-7)

- The Site R sampling station (AA-R-1)
- The sampling location closest to Site S (AA-S-1).

For dioxins analysis, unfiltered groundwater samples were collected at the top, middle, and bottom of the aquifer.

Because of the higher turbidity of some of the groundwater samples, filtered SVOC and metals samples were also collected following the issuance of the July 12, 2002 field clarification log regarding time limit on purging to verify that analytical results were attributable to the groundwater and not the suspended sediment. Tables 3-6a through 3-6f present a sample and analysis summary for alluvial aquifer groundwater samples.

The alluvial aquifer groundwater samples were collected by allowing the groundwater to flow directly into the laboratory supplied sample containers. Each container was labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each label was sealed with clear polyethylene tape and the samples were logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C.

The groundwater samples, along with the corresponding chain-of-custody form, were shipped via an overnight delivery service to Severn Trent Laboratories in Savannah, Georgia for analysis of VOCs, SVOCs, pesticides, herbicides, PCBs, metals, and several geochemical parameters, which include methane, nitrate, carbon dioxide, alkalinity, and sulfate, and to Severn Trent Laboratories in Sacramento, California for analysis of dioxins. Due to the short hold time, ferrous iron (a geochemical parameter) was analyzed in the field with a spectrophotometer.

Upon completion of each alluvial aquifer boring, each Geoprobe® hole was sealed with grout from the bottom up using the Geoprobe® rods as a tremie pipe and the surface was returned to its original condition. Purge water was placed in 55-gallon drums that were labeled, sealed, and staged on-site. The sampling equipment (Geoprobe® rods) was decontaminated between borings using a steam pressure washer.

Photographic documentation of the alluvial aquifer sampling is provided in Appendix A.

Groundwater sampling forms presenting information related to alluvial aquifer sampling are provided in Appendix D.

3.4.2 Bedrock Wells

3.4.2.1 Installation

Six bedrock-monitoring wells were installed utilizing sonic drilling technology. Four bedrock-monitoring wells designated Bdrk-O-1, Bdrk-P-1, Bdrk-R-1, and Bdrk-S-1 were installed downgradient of Sites O, P, R, and S, respectively. Two bedrock wells, designated Bdrk-Q-1 and Bdrk-Q-2, were installed along the western edge of Site Q. The location of each well was chosen prior to mobilization to the field and based on historical groundwater flow data for the Sauget, Illinois region. Locations of bedrock monitoring wells are presented in Figures 3-6a through 3-6e.

Bedrock well borings were advancing using sonic drilling techniques. Soil samples were continuously collected by advancing both a 4-inch soil core barrel and 6-inch temporary sonic override casing through the subsurface soils to the top of the competent bedrock. Competent bedrock was defined as a "clean" rock with no clay in the matrix and was confirmed by a visual, in-field inspection performed by URS and agreed upon by the USEPA Region V representative (CH2MHill). The 4-inch core barrel and 6-inch override casing were then advanced an additional 5 feet into the competent bedrock. The 6-inch override casing was left at this point to serve as an isolation casing to prevent movement of contaminants into the bedrock. A 1-foot thick bentonite seal was also placed in the bottom of the casing prior to additional drilling into the bedrock to further tighten the seal. The bentonite used for the seal was allowed to hydrate for a minimum of 30 minutes before drilling resumed. The bedrock was then cored a distance of 23 to 24 feet using the 4-inch core barrel and sonic technique, resulting in a 4-inch diameter open rock hole after the core barrel was removed. Each borehole was advanced 3 to 4 feet below the desired depth to allow the fine particles, which were suspended in the drilling fluid to settle out once drilling and water circulation stopped. The completion depths of each bedrock monitoring well are summarized in Table 3-5 and total borehole depths are given on well construction diagrams presented in Appendix C.

Soil and bedrock was continuously inspected and logged according to the USCS and standards outlined in Appendix J of the FSP during drilling operations. Information pertaining to the

subsurface materials and drilling conditions was recorded in the field on a standard Field Boring Log form. Boring Logs are provided in Appendix B.

Two-inch diameter PVC monitoring wells were constructed in each borehole to a depth of 25-feet below the competent bedrock surface. The monitoring wells were installed using Schedule 40 PVC well screen and riser pipe. The well screen consisted of a 5-feet long section of 0.010-inch slotted PVC well screen. A sand filter pack consisting of 20/40 sieve size silica sand was installed from the bottom of the well-screen to a distance of 3 feet above the top of the screen in each well. A 3-foot thick bentonite chip seal was then placed immediately above the sand filter pack. The remaining annular space was filled with a bentonite and cement grout (grout) to a distance of 3 feet bgs. The grout was installed through the bottom of the 6-inch override casing via the tremie method. Grout was always maintained inside the temporary casing to protect against formation collapse. The override casing was extracted from the borehole at an equivalent rate to that of the grout being introduced into the annular space of the well. In addition, the override casing was resonated during its removal to assist in the formation of an effective seal between the grout and surrounding subsurface materials. The upper 3 feet of annular space was filled with concrete. Wellheads were either finished as above ground completions or flush-mount completions, depending on the wells location and potential interference to vehicular traffic. Keyed-alike locks were then placed on each well for security purposes. Well construction diagrams are provided in Appendix C.

3.4.2.2 Development

The objective of groundwater monitoring well development was to remove fines from well screen and filter pack so that representative groundwater samples could be collected. Generalized procedures stated in Appendix H of the FSP were followed during bedrock well development.

The water elevation in each well was measured from the TOC to the nearest $1/100^{th}$ of a foot using a petroleum/water interface probe. The total depth of the well from the TOC was also measured at this time. Water level measurements, the total well depth, and the screened intervals for each bedrock monitoring well are summarized on Table 3-5. These measurements were used to calculate the well volume of water for each monitoring well.

Development of the monitoring wells was accomplished by lowering a Grundfos® submersible pump equipped with the proper length of disposable polyethylene discharge tubing into the well and placed approximately 2.5 feet above the bottom of the well (near the middle of the well screen). The pump was turned on and the flow regulated to a rate to allow sediments to be removed without causing the pump to clog. The development water was discharged directly into DOT approved 55-gallon drums, which were labeled with the well identification number, site location, date and contents. Development continued until a minimum of five well volumes of water had been removed from the well and the pH, conductivity, and temperature had stabilized. Readings were collected after each well volume of water had been removed and considered stabilized when two consecutive measurements were within the following criteria:

- ± 0.25 units for pH
- ± 10% for specific conductivity
- ± 1°C for temperature.

Monitoring wells that purged dry during development were purged dry three times. The water was allowed to recharge to static conditions between each cycle of purging. If the well did not recharge to static conditions within 24 hours the well was considered dry and development was complete.

3.4.2.3 Sampling

Bedrock wells were sampled in September 2002, January, April, and June 2003 according to generalized procedures outlined in Appendices H and I of the FSP. The purpose of the bedrock sampling was to determine the extent of organic and inorganic constituent vertical migration from the sites. Groundwater samples collected from bedrock monitoring wells were analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals and several geochemical parameters.

Prior to sampling, the water level in each well was measured from the TOC to the nearest $1/100^{th}$ of a foot using a petroleum/water interface probe and recorded. Water elevations in the bedrock wells are provided in Table 3-5. These measurements were used to calculate one well volume of water for each monitoring well.

A Waterra® pump equipped with the proper length of disposable discharge tubing was lowered into the well and placed approximately 2.5 feet above the bottom of the well (near the middle of

the well screen). The pump was turned on and the flow adjusted to not exceed 1 L/min. The flow rate was checked periodically to ensure a constant low-flow rate was maintained. Water was discharged into a graduated pail and then transferred to DOT approved 55-gallon drums, which were labeled with the well identification number, site location, date and contents. Purging continued until a minimum of three well volumes of water had been removed from the well and the pH, conductivity, and temperature had stabilized. Readings were collected after each well volume of water had been removed and considered stabilized when two consecutive measurements were within the following criteria:

- ± 0.25 units for pH
- ± 10% for specific conductivity
- ± 1°C for temperature.

In addition, turbidity, DO and ORP were measured and recorded.

After purging was complete, groundwater samples were collected using the Waterra® pump with a flow rate of 1 L/min or less. Samples were discharged directly into laboratory supplied sample containers. To minimize volatilization, samples obtained for VOC analysis were filled first. Each sample container was labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed.

After sample collection, each label was sealed with clear polyethylene tape and the samples were logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C.

The groundwater samples along with the corresponding chain-of-custody form were shipped via an overnight delivery service to Seven Trent Laboratories in Savannah, Georgia for analysis of VOCs, SVOCs, pesticides, herbicides, PCBs, metals, and several geochemical parameters, which include methane, nitrate, carbon dioxide, alkalinity, and sulfate, and to Severn Trent Laboratories in Sacramento, California for analysis of dioxins. Groundwater sampling forms presenting information relating to the development and sampling of each monitoring well are presented in Appendix D.

3.4.2.4 Thin Section Analysis

Sections of bedrock were collected every 2 feet over the total length of recovery of the bedrock core for petrographic thin section analysis. Sections of core approximately 2-inches thick were cut from the core, labeled relative to total depth below ground surface and shipped to Texas Petrographic Services, Inc. for thin section preparation. The thin-sections were subsequently shipped to Omni Laboratories for petrographic thin section analysis of porosity under chain-of-custody control. Copies of the chain-of-custody documentation relating to thin section analysis are provided in Appendix E.

Photographic documentation of bedrock monitoring well installation, development and sampling, as well as soil and rock samples are provided in Appendix A.

3.4.3 Piezometers

3.4.3.1 Installation

Twenty-seven 1-inch piezometers were installed in the alluvial aquifer at nine locations, with three piezometers placed in each boring (clusters), utilizing sonic drilling technology. Three piezometer clusters were installed at the upgradient portion of the study area, adjacent to Mississippi Avenue (Route 3). Three piezometer clusters were installed midway between the Mississippi River and Route 3. The third group of three piezometer clusters were installed at the downgradient end of the study area adjacent to the Mississippi River. Piezometer locations are shown on Figure 3-2. Each piezometer cluster consists of three small-diameter (1-inch) piezometers. In each cluster, one piezometer was completed in the shallow portion of the alluvial aquifer, one piezometer was completed in the intermediate portion of the alluvial aquifer, and one piezometer was completed in the deep portion of the alluvial aquifer.

All piezometer borings were completed by continuously advancing a 4-inch soil core barrel and 6-inch temporary sonic override casing through the overburden soils to the underlying bedrock. The bedrock was then slightly penetrated so that an assessment of its condition could be made. Bedrock depth and condition were confirmed by a visual, in-field inspection performed by URS and agreed upon by CH2MHill, the USEPA Region V representative (CH2MHill). During the advancement of the core barrel and override casing, soil and bedrock was continuously inspected and logged according to the USCS and standards outlined in Appendix J of the FSP. Information

pertaining to the subsurface materials and drilling conditions was recorded in the field on a standard Field Boring Log form. Boring Logs can be viewed in Appendix B.

The 6-inch override casing was temporarily left in place and the 4-inch soil core barrel was removed. An 8-inch diameter override casing was then advanced to the depth in which the bottom of the intermediate piezometer screen was to be located. The depth of the intermediate piezometer screen was determined based on the depth to bedrock and depth in which groundwater was first encountered. After the 8-inch casing was in place at the pre-determined depth, the deep piezometer was installed. The portion of the borehole located beneath the bedrock surface was backfilled with bentonite chips. A 0.5 to 1-inch thick cushioning layer of silica filter sand was placed on top of the bentonite backfill to a depth consistent with the bedrock surface. One-inch diameter Schedule 40 PVC well screen and riser was installed through the 6-inch override casing to the depth of the bedrock. Each well screen consisted of a 10-foot long section of 0.010-inch slotted PVC well screen. A sand filter pack consisting of 20/40 sieve size silica sand was installed from the base of the deep piezometer to a distance of 2 feet above the top of the well screen. Bentonite chips were placed above the sand filter pack to a distance of 5 feet beneath the depth at which the intermediate piezometer well screen was placed. The bentonite was installed as the override casing was removed and bentonite levels were maintained up inside the casing as it was extracted so borehole collapse did not occur.

The intermediate piezometer was installed second at a pre-determined depth based on total depth to bedrock and depth to groundwater. One-inch diameter Schedule 40 PVC well screen and riser was installed through the 8-inch override casing to the pre-determined depth. Each well screen consisted of a 10-foot long section of 0.010-inch slotted PVC well screen. A sand filter pack consisting of 20/40 sieve size silica sand was installed from a depth of 5-feet beneath the base of the intermediate piezometer to a distance of 2 feet above the top of the well screen. Bentonite chips were placed above the sand filter pack to a distance of 5 feet beneath the depth at which the shallow piezometer well screen was placed. The bentonite was installed as the 8-inch override casing was removed and bentonite levels were maintained up inside the casing so that borehole collapse did not occur.

The shallow piezometer was installed third. This piezometer was placed so that the midpoint of the screen approximately intersected the groundwater table. One-inch diameter Schedule 40 PVC well screen and riser was installed through the 8-inch override casing to the pre-determined

depth. Each well screen consisted of a 10-foot long section of 0.010-inch slotted PVC well screen. A sand filter pack consisting of 20/40 sieve size silica sand was installed from a depth of 5-feet beneath the base of the shallow piezometer to a distance of 2 feet above the top of the well screen. Bentonite chips were placed above the sand filter pack to a distance of 3 feet bgs. Concrete was placed in the remaining annular space and the piezometers were either completed as aboveground or flush-mount wellheads. Well construction diagrams of each piezometer are provided in Appendix C.

Photographic documentation of the piezometer installation and the soil and bedrock samples is provided in Appendix A.

3.4.3.2 Geotechnical Sample Collection and Analysis

Geotechnical samples were collected from each of the three major hydrologic units at the nine piezometer cluster locations. Geotechnical samples were collected with polycarbonate liners placed inside a modified 4-inch sonic core barrel. Samples were collected during the initial advancement of the 4-inch core barrel and 6-inch override casing. Samples were collected from the approximate depths in which the deep, intermediate, and shallow piezometer well screens were placed. Sample collection depths were estimated during drilling based on initial depth to the groundwater table and knowledge of the approximate depth to bedrock within the SA2 Project area. Upon retrieval from the borehole, the polycarbonate liners were capped, sealed and labeled. The samples were shipped under chain-of-custody control to the URS geotechnical laboratory located in Totowa, New Jersey. Samples were analyzed for:

- Grain size
  - Particle size distribution
- Porosity
- Bulk density
- Specific gravity
- Moisture content
- pH
- Total organic carbon.

3.5 SURFACE AND SUBSURFACE SOIL SAMPLING

A total of 38 surface soil samples (0 to 0.5 feet) and 30 subsurface soil samples (0.5 to 6 feet) were collected. These discrete samples were collected at the location of each waste boring and five off-site sample locations, four of which corresponded to the four upgradient alluvial aquifer locations and one south of Site Q in an agricultural field. These samples are intended to provide information for the HHRA and the BERA. Waste and soil sampling locations were selected based on the 1998 Ecology and Environment Report, the results of the aerial photograph analysis, and the soil gas and magnetometer surveys conducted as a part of the SSP. The locations of surface soil samples (located at waste borings) are presented on Figures 3-5a through 3-5e. Photographic documentation is provided in Appendix A.

Surface and subsurface soil samples in Sites O, S, and R were collected using a Geoprobe® to advance a 2-inch diameter by 4-feet long Macro-Core™ soil sampler with acetate liners. Due to the small amount of sample collected in the 2-inch Macro-Core™ soil sampler from 0 to 0.5 feet and the amount of sample required to fill the sample containers, additional surface soil was collected next to the borehole with a stainless steel hand auger. If additional subsurface soil was required to fill the required sample volume, additional Geoprobe® holes were advanced adjacent to the original borehole.

In Sites P and Q, the Geoprobe® was unable to advance the sampler to the desired depths due to the presence of a substantial amount of rubble, therefore, the four surface and subsurface soil samples in Site P and the twelve surface and subsurface soil samples in Site Q were collected using sonic drilling technology. Continuous soil samples were collected using a 4-inch diameter core barrel and a 6-inch override casing. The subsurface stratigraphy was logged during drilling operations by a qualified field scientist in accordance with the USCS and standards outlined in Appendix J of the FSP. The field scientist noted soil attributes such as color, particle size, consistency, moisture content, structure, plasticity, odor (if obvious) and organic content (if visible). Soil samples from each boring were visually evaluated for evidence of impact and screened in the field using a PID. These observations were noted on Field Boring Logs. Boring Logs are presented in Appendix B.

The soil samples were transferred to laboratory-supplied containers. VOC samples were collected using a 5-gram Encore® sampler. Each sample container was labeled with a sample

identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each label was sealed with clear polyethylene tape and the samples were logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C.

The surface soil samples, along with the corresponding chain-of-custody form, were shipped via an overnight delivery service to Seven Trent Laboratories in Savannah, Georgia for analysis of VOCs, SVOCs, pesticides, herbicides, PCBs, metals, and to Severn Trent Laboratories in Sacramento, California for analysis of dioxins. Table 3-7 presents a sample and analysis summary for the surface soil samples.

After sampling was completed, each soil boring was continued as a waste boring. Excess soil cuttings and acetate liners were placed in 55-gallon drums that were labeled, sealed, and staged on-site. Sampling equipment (core barrel, override casing, drill rig) was decontaminated between borings using a steam pressure washer.

Photographic documentation of the surface and subsurface soil sampling is provided in Appendix A.

3.6 AIR SAMPLING

Upwind and downwind ambient air sample sets were collected to determine the tendency of site constituents to enter the atmosphere and local wind patterns. Each sample set consisted of two upwind and two downwind samples. Four individual sample sets were collected from four areas within the SA2 project area. Sample designations are as follows:

- AIR-P-1
- AIR-P-2
- AIR-P-3
- AIR-P-4
- AIR-R-1
- AIR-R-2
- AIR-R-3
- AIR-R-4
- AIR-Q-1
- AIR-Q-2
- AIR-Q-3
- AIR-Q-4
- AIR-Q-5
- AIR-Q-6
- AIR-Q-7
- AIR-Q-8.

Sampling locations are shown on Figure 3-2. Each air sample was analyzed for VOCs, SVOCs, pesticides, PCBs, dioxins, and metals. In addition, two duplicate air samples were collected from sampling locations Air-R-4 and Air-Q-6 and analyzed for the same parameters. During the collection of the duplicate sample at Air-Q-6 the PM2.5FRM sampler used for the collection of the metals samples malfunctioned. Due to this malfunction, an additional duplicate for the analysis of metals only was collected at location Air-Q-4.

Twenty-four hour cumulative duration sorbent tube/PUF/PM2.5 samples were collected over a one-day period at each sampling location, using the sampling protocols provided in Appendix L of the FSP. Two upwind and downwind samplers were installed at each site during weather likely to produce emissions (e.g., hot and dry conditions in August). Sampling locations were selected in the field with the concurrence of the USEPA Region V representative (CH2MHill). Sorbent tube samplers were used for VOC data collection. PUF samplers were used for SVOC, PCB, pesticide, and dioxins data collection. PM2.5 samplers were used for metal data collection.

Ambient air sample collection was required to measure levels of airborne contaminants that may be emanating from the site. A 24-hour sample duration period was used to average the air emission differences that may occur from the daytime to nighttime cycle from on-site and off-site conditions and activities. Also, air sample collection locations were positioned on the site to collect upwind and downwind samples for differentiation of constituents originating from the surrounding areas and those originating from the site. The sample protocol dictated that site samples be collected over a one-day time period on a warm, dry day.

The level of detection for SVOCs required by USEPA Region V considered sensitivity and selectivity to analyze complex samples. Based on this need, the analytical method of choice was gas chromatography coupled with GC/MS for detection. Based on the GC/MS analytical method and its sensitivity level, the air sample volume was to exceed 325 standard cubic feet. This enabled the collection of a sufficient quantity of SVOCs to meet the level of detection required by USEPA Region V.

The sample method used to meet the above requirements for SVOC measurement was USEPA Method TO-13, as identified in the Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air (USEPA, 1988). This method uses a Graseby/General Metal Works, Inc. high volume air sampling unit or equivalent for sample collection. Sample

collection consisted of drawing an ambient air sample at a high volume flow rate through a PUF collection media over a 24-hour time period. Method TO-15 was used to collect and analyze samples for VOCs. Method TO-4 was used to collect and analyze samples for pesticides and PCBs. Method TO-9 was used to collect and analyze samples for dioxins.

The following procedure were used for the set up of air sampling units and collection of ambient air samples:

- Placed the sorbent tube samplers, PUF samplers, and PM2.5 samplers at upwind and downwind locations.
- Sampling positions were located in an unobstructed area, at least 2 meters from any obstacle to airflow. Sample locations were selected in the field with the concurrence of the USEPA Region V representative (CH2MHill).
- No local power supply was available at the sampling locations. Therefore, portable, diesel-powered generators were positioned at downwind locations from the sample collection positions to supply electricity for sampler operation.
- Wind direction and velocity readings were recorded.
- Sample collection protocols identified in Appendix L of the FSP for sample preparation, calibration, collection, laboratory preparation and shipment, and calculations were followed at all times during air sampling activities.

Upon the completion of each 24-hour sampling period, the samplers and generators were transported to the next pre-designated sampling location, placed, and restarted. Air samples were collected and transported in a chilled cooler under chain-of-custody control to Severn Trent Services, Inc. analytical laboratories located in Savannah, Georgia and Sacramento, California for analysis. The chain-of-custody documents were sealed inside and custody seals were placed across the lid openings of each cooler during shipment to the analytical laboratories.

Photographic documentation of the air sampling is provided in Appendix A.

3.7 STORMWATER SAMPLING

In an effort to characterize run-off from the site during storm events, stormwater run-off grab samples were collected from two downgradient locations located in Site Q and one located in

Site R. After two months (June and July 2002) of field activities without any observed run-off producing rainfall events, a visual reconnaissance survey was conducted of the riverbank at Sites Q and R to identify sampling locations following a significant storm event on August 5 and 6, 2002. Two downgradient locations in Site Q and one location in Site R were identified as sample locations. The stormwater run-off sample locations are shown on Figure 3-8. The SA2SG representative and the USEPA Region V representative (CH2MHill) subsequently approved the sampling locations. Three automated stormwater samplers were installed, tested, and programmed, at the locations.

Sample locations were placed within the primary drainage route leading from the site to the Mississippi River. Stormwater run-off sampling was conducted at Sites Q and R because they are on the wet side of the floodwall and levee. The other three sites (O, P, and S) are on the dry side of the floodwall and levee and therefore have no drainage route to the Mississippi River. A first flush sample was collected utilizing an automated sampling device. A first flush sample is one collected at the very beginning of a storm event (as the first flow comes through). Collection of a first flush sample insures that any contamination on the ground surface prior to the storm event will be collected before it has the opportunity to wash away. In addition, after each sampling event, a 72-hour period without additional rainfall had to occur before the next sample could be collected.

Stormwater run-off samples were collected at each of the three sampling locations in Sites Q and R (Storm-Q-1, Storm-Q-2, and Storm-R-1) on September 18 and October 3, 2002, which were the first two run-off producing rainfall events following installation of the automated samplers. The FSP called for the collection of stormwater run-off samples at each location during three storm events to determine variability of constituent concentrations in site run-off. Following the successful collection of samples after the first two rainfall events, numerous attempts were made to collect the third and final sample. On two other occasions (October 25 and 29, 2002) rainfall events produced run-off, but incomplete samples were collected in each of the three samplers because of leaves plugging the channel and intake screen of the samplers and because of tampering with the samplers. It appeared as though the inlet screen was removed from the drainage route and that someone had accessed the control pad of the sampling device.

In November, freezing conditions began and precipitation events following that time mostly consisted of snowfall for the remainder of the winter season. In addition, a sand berm was

constructed around sampling location R-1 by the property owner in preparation for upcoming construction planned for this area. For these reasons, stormwater sampling was terminated in early December 2002. Therefore, due to site and weather conditions, the third sample was not feasible to collect during this period.

The two complete stormwater run-off samples, collected on September 18 and October 3, 2002, were collected with an automated ISCO sampler. Ice was placed in the automated sampler around sample containers before a forecasted storm event. A decontaminated plastic container was placed in the stormwater run-off drainage route to assist in collecting the stormwater run-off. The inlet screen of the sampler was placed in this container. During a storm event, the automated sampler would pump water from the plastic container into twelve 1-liter glass jars arranged inside the sampler. After the rainfall event, the stormwater run-off samples were transferred into the laboratory provided sample containers. Each sample container was labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each label was sealed with clear polyethylene tape and the samples were logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C.

The stormwater samples, along with the corresponding chain-of-custody form, were shipped via an overnight delivery service to Seven Trent Laboratories in Savannah, Georgia for analysis of VOCs, SVOCs, pesticides, herbicides, PCBs, metals, and to Severn Trent Laboratories in Sacramento, California for analysis of dioxins. Table 3-8 presents a sample and analysis summary for the stormwater samples.

After each sampling event, including unsuccessful attempts, the 1-liter glass jars, the plastic container where the inlet screen was placed, and the tubing associated with the ISCO sampler was decontaminated using an alconox wash and rinse.

3.8 SEEP SAMPLING

In order to assess the presence of seeps and their impacts on the Mississippi River, seep grab samples were collected from one location in Site R and two locations in Site Q. A visual reconnaissance survey was conducted on August 6, 2002 along the riverbank adjacent to Sites Q and R. Several seeps were observed along the riverbank adjacent to both Sites Q and R, and two potential sample locations were identified in each site. The locations of any seeps observed were

photographed. A photographic log is presented in Appendix A. The seep sample locations are shown on Figure 3-8.

At each sampling location along the riverbank adjacent to Sites Q and R, several smaller seeps in close proximity to each other were sampled as a single location. At the northern Site R boundary, the first identified location was in the sand next to a concrete structure, which is believed to have previously housed a wastewater treatment plant outfall pipe. Due to insufficient quantity collected over the sample period, a seep sample was not able to be collected from this location. The second identified seep location (Seep-R-1) adjacent to Site R was located approximately 30 feet from the shoreline in a rocky area. This sampling location consisted of several small seeps along a section approximately 100 feet in length. The first identified location (Seep-Q-1) adjacent to Site Q was along the central section of the site and consisted of two large seeps and several smaller seeps along a section approximately 200 feet in length. The second location (Seep-Q-2) adjacent to Site Q was west of the site boundary in southern Site Q and consisted of numerous seeps along a section approximately 150 feet in length.

Seep samples (Seep-R-1, Seep-Q-1, and Seep-Q-2) were collected on August 8 and 9, 2002. Prior to sample collection, a decontaminated plastic container was placed in the seep drainage path to assist in collecting the seep sample. After allowing the seep material to collect in the containers for approximately 24 hours, the seep samples were transferred into laboratory provided containers. Each sample container was labeled with a sample identification number, site name, sampler's initials, date and time of sample collection, preservative, and the parameters to be analyzed. After sample collection, each label was sealed with clear polyethylene tape and the samples were logged on a chain-of-custody form, packaged to prevent damage during shipment, and cooled with ice to 4°C.

The seep samples, along with the corresponding chain-of-custody form, were shipped via an overnight delivery service to Seven Trent Laboratories in Savannah, Georgia for analysis of VOCs, SVOCs, pesticides, herbicides, PCBs, metals, and to Severn Trent Laboratories in Sacramento, California for analysis of dioxins. Table 3-9 presents a sample and analysis summary for the seep samples.

3.9 SLUG TESTING

Slug tests were performed on each bedrock monitoring well and each piezometer to determine the hydraulic conductivity of the soils surrounding the screened interval. Rising and falling head tests were performed using decontaminated PVC slugs filled with sand or distilled water, a data logger and an electronic water level indicator. For the bedrock monitoring wells, the slugs consisted of an approximately 5-foot long, 1.5-inch diameter PVC pipe filled with fine silica sand and capped at both ends. The slugs for the piezometers consisted of an approximately 5-foot long, 0.5-inch diameter PVC pipe with a bottom cap filled with distilled water.

Each well/piezometer was opened and the water level was allowed to equilibrate for a minimum of 30 minutes prior to initiation of the slug tests. The static water level was gauged and total depth of each well/piezometer was measured to the nearest 0.01 foot using an electronic water level indicator and then the electronic data logger was installed into the well in preparation for each test. For the falling head test, the slug was instantaneously introduced into the well, taking care to fully submerge it and not hit the data logger/transducer, and the initial displacement was measured. Measurements were continually recorded until the water level had stabilized or until 90% of the excess head had dissipated.

For the rising head tests, the full bailer was removed instantaneously from the well and the initial displacement was measured. Measurements were continually recorded until the water level had stabilized or until the 90% of the drawdown had dissipated.

The resulting slug test data was imported into the AQTESOLV® groundwater data reduction program, version 2.5, which calculated the hydraulic conductivity for the portion of the aquifer immediately adjacent to the screen interval.

3.10 HEALTH AND SAFETY

The RI field activities were conducted in accordance with the RI/FS Support Sampling Plan Volume 3C, Health and Safety Plan (HASP) (URS, 2001a).

The fieldwork was conducted in Modified Level D, Level C and Level B personal protective equipment (PPE). All intrusive work at Site R and the anomaly trench in Site S was performed in Level B PPE. The beginning of each intrusive activity and the sampling of the leachate

monitoring well in Site R was performed in Level C PPE. The remainder of the intrusive activities were performed in Modified Level D PPE and all non-intrusive activities, such as surveying, was performed in standard Level D PPE.

The following instruments were used as indicators of air quality during the field activities:

- PID air monitor with 10.2 and 11.7 amp probes
- Combustible gas meter (CGM)
- Real-time aerosol monitor (RAM)
- Draeger pumps and colorimetric indicator tubes.

Health and safety related information was primarily recorded in field logbooks and on Air Monitoring Data Sheets.

3.11 QUALITY ASSURANCE

3.11.1 Field Audit

A field audit was conducted August 2, 7, and 14, 2002. The objective of the audit was to monitor conformance with the procedures and work items outlined in the approved work plan. The following items were reviewed during the audit: field log books and calibration records; the sample collection process; sampling procedures; decontamination procedures; sample labeling, custody, and packing procedures. The results of the audit indicated the fieldwork was being performed in accordance with the work plan. Field audit documentation is presented in Appendix F.

3.11.2 QA/QC Samples

Quality Assurance/Quality Control (QA/QC) samples were collected during the field activities. The QA/QC samples consisted of:

- Sample duplicates
- Matrix spike samples (MS)
- Matrix spike duplicate samples (MSD)
- Trip blanks and field blanks.

These samples were collected in accordance with Appendix B of the FSP. A summary of the QA/QC sample collection is provided in Table 3-10.

3.12 INVESTIGATION DERIVED WASTE DISPOSAL

During field activities, the IDW (purge water and solid waste) was stored on-site in double-walled tanks and roll-off boxes. After the completion of field activities the purge water was transferred to ABRTF. The solid waste was shipped in the roll-off boxes to Onyx Environmental in Port Arthur, Texas for incineration as a hazardous waste. The IDW disposal manifests for the solid waste are presented in Appendix G.

SECTIONFOUR Data Validation

4.1 INTRODUCTION

During the later half of 2002 and early 2003, a number of environmental samples were collected in accordance with the USEPA-approved work plans for the SA2 RI/FS effort (SSP and Addendum 1 to Volume 2A, dated June 17, 2002). The data validation effort employed for the SA2 project was conducted in accordance with the specifications of the approved Data Validation Plan (URS, 2001b) with the following general exceptions:

For the polychlorinated-p-dioxins and polychlorinated dibenzofurans analyses, the laboratory did not analyze samples greater than a 10x dilution due to the possibility of either the surrogates and/or the internal standards being diluted out. There is no discernable negative impact on data quality.

Data validation reports for each individual sampled delivery group (SDG) received by the project chemistry team from the laboratory are included as Appendix H. It is important to note that the discussion herein is limited to results for field samples only.

4.2 SITE CHARACTERIZATION PARAMETERS

The work plan established a standard set of analytical parameters to be used to characterize Sites O, P, Q, R and S and which would be used in the development of the ecological and human health risk assessments for these sites. These parameters included VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins and metals. A discussion of the data validation issues associated with all of the field samples from all media for which these analyses were performed is included below. All analytical methods referenced are standard EPA-approved methods as discussed in the work plan.

Tables 4-1 through 4-13 present a summary of the data qualifiers applied during the validation process. These tables are presented in two parts. On the left had side is given the absolute number of data qualifiers applied sorted by reason code. The data qualifiers are referred to in the table as "Flags" and the reason code (e.g., a code that indicates why each data qualifier was applied) is abbreviated "RC". On the right, these values are presented as percentages. In the center, the fraction of all results flagged for each data qualifier/reason code combination.

It is normal and to be expected that data qualifiers will be applied to the data for a wide variety of reasons, most of which are beyond the control of either the field team or the laboratory, such as matrix effects or limited amounts of analyte identified in the field or laboratory background. Thus, a detailed and exhaustive discussion of every flag applied would serve little purpose other than to make the identification of significant issues difficult to observe. For the sake of clarity and of brevity, therefore, the discussion below is limited to examination of observations that apply to a significant portion of the data or which have a significant bearing on the interpretation of the data.

In general terms, "significance" is defined in this case according to the guidelines in the USEPA's Risk Assessment Guidance for Superfund (RAGS). Specifically, data flagged "R", indicating serious quality control issues that may result in false negative conclusions are identified and discussed in this report and should be excluded from use in data analysis under most circumstances. On the other hand, data qualified as "U", indicating background contamination from one or more sources or "J", indicating an estimated result, are usable for data analysis and decision making purposes.

4.2.1 VOCs By Method 8260B

Overall, VOC data displayed very good performance. Only 130 of 18,429 or 0.7 percent of the data were flagged "R". The primary cause of these "R" flags is a well documented and widely recognized limitation of the analytical method relative to the analysis of acetone (ketone) and bromomethane (gas). Specifically, the ketones, as a class, have historically displayed poor purging efficiency due to their relatively high solubility. The relatively high volatility of the gasses causes rapid degradation of standards through evaporation. These same analytes often display poor trapping ability in the sample introduction system. Acetone and bromomethane were rejected due to response factors less than the protocol specification which effect was also observed in the LCSs. It is important to note that the protocol specification for minimum response (i.e., 0.05) was established many years ago under the USEPA CLP Program. Modern instruments are capable of much better and reliable identification and quantitation at lower response levels. Other than these two analytes, the occurrence of "R" flags was generally incidental and widely dispersed, except in the air matrix where a more general problem in the LCS data was observed.

In summary:

- **Precision:** With the exception of acetone and bromomethane, the precision of these data is generally acceptable. The acetone and bromomethane data should be used with caution when using the data for decision-making.
- **Accuracy:** The accuracy of these data is generally acceptable.
- **Representativeness:** The representativeness of the data is generally acceptable.
- **Completeness:** Except for the acetone and bromomethane anomalies mentioned above, the data display an acceptable level of completeness. In the air matrix, the data user is cautioned to review data qualification more carefully as greater than 5% of the data are flagged "R".
- **Sensitivity:** A small number of analytes required dilutions due to concentrations exceeding the calibration range of the instrument and a few other samples were analyzed at dilutions due to possible matrix interference.

4.2.2 SVOCs By Method 8270C

SVOC data also displayed very good sampling and analytical control. Of the over 45,000 analyses 248 (1.1%) were flagged "R". Matrix effects as evidenced by matrix spike, internal standard and surrogate recovery failures account for over 75% of those flags. An additional 12.5% of the flags are attributable to a single sample that appears to have been affected by serious "carryover" from a previous analysis. In fact these results might have been flagged "U" as easily as "R". The balance of the "R" flags are attributable to widely dispersed failures in LCS data.

In summary:

- **Precision:** The precision of the data is generally acceptable.
- **Accuracy:** Except for the small number of samples affected by low surrogate recoveries, the accuracy of the data is generally acceptable. The samples affected by low surrogate recoveries should be used with caution.
- **Representativeness:** The representativeness of the data is generally acceptable.

- **Completeness:** The completeness of the data is generally acceptable. Only the air matrix displays greater than 5% "R" flags, attributable to matrix effects.
- **Sensitivity:** A small number of analytes required dilutions due to concentrations exceeding the calibration range of the instrument and a few other samples were analyzed at dilutions due to possible matrix interference.

4.2.3 Pesticides By Method 8081a

Pesticide results displayed acceptable overall performance with 240 of 10,991 (2.2%) results flagged "R". Approximately 65% of the failures were attributable to matrix effects, primarily indicated by surrogate failure. The air matrix data was severely impacted by the failure of the LCS for the three BHC compounds, which affected a large number of samples.

In summary:

- **Precision:** A modest number of samples were flagged due to calibration anomalies and to dual column imprecision. Affected results should be used with the knowledge that these results may display a more than usual bias and/or variability.
- **Accuracy:** The accuracy of some data may display more than usual bias and/or variability due to low surrogate recoveries. These results should be used knowing that results may be biased high or low. Approximately 10% of these flagged results were flagged "R". These results should not be used for data interpretation.
- **Representativeness:** The representativeness of the data is generally acceptable.
- **Completeness:** The stormwater and air matrices displayed greater than 5% "R" flags due to, in the case of stormwater, matrix effects and in the case of the air matrix, an apparent method limitation in that the BHC analytes did not recover properly.
- **Sensitivity:** A small number of analytes required dilutions due to concentrations exceeding the calibration range of the instrument and a few other samples were analyzed at dilutions due to possible matrix interference.

4.2.4 Herbicides By Method 8151

The herbicide data displayed 170 "R" flagged results out of a total of 5,069 analyses (3.4%). 75% of these were observed in the sediment fraction and are attributable to a mechanical problem during the analysis of a single batch of samples (the LCS extraction vessel developed a leak during the concentration part of the extraction). It is worth noting, however, that the matrix spike associated with this batch displayed acceptable results and that these data, although flagged "R" according to the validation protocol, may well be usable.

In summary:

- **Precision:** A modest number of data was flagged due to dual column imprecision. Affected results should be used knowing that the imprecision of the results between columns may cause greater than usual variability.
- **Accuracy:** The accuracy of some data may display a greater than usual bias due to continuing calibration anomalies or low surrogate recoveries. These results should be used with the knowledge that the results may display more than usual bias and/or variability.
- **Representativeness:** The representativeness of the data is generally acceptable.
- **Completeness:** The completeness of the data is acceptable overall but the data for the sediment fraction, in particular, display greater than 5% "R" flags. In the judgment of the reviewer, even these data may be used, albeit cautiously.
- **Sensitivity:** A small number of analytes required dilutions due to concentrations exceeding the calibration range of the instrument and a few other samples were analyzed at dilutions due to possible matrix interference.

4.2.5 PCBs By Method 680

Only nine of the 5,069 PCB results (0.2%) display "R" flags. These are attributable to matrix effects. No individual fraction displays greater than 5% "R" flags.

In summary:

- **Precision:** The precision of the data is generally acceptable.
- **Accuracy:** The accuracy of the data is generally acceptable.
- **Representativeness:** The representativeness of the data is generally acceptable.
- **Completeness:** The completeness of the data is generally acceptable.
- **Sensitivity:** A small number of analytes required dilutions due to concentrations exceeding the calibration range of the instrument and a few other samples were analyzed at dilutions due to possible matrix interference.

4.2.6 Dioxins/Furans By Method 8280A/SW8290

A very small number of results, 11 of 9,317 (0.1%) were flagged "R" due to holding time exceedance.

In summary:

- **Precision:** The precision of these data is generally acceptable, even though a small amount of data was flagged due to calibration anomalies.
- **Accuracy:** The accuracy of these data is generally acceptable.
- **Representativeness:** The representativeness of the data is generally complete.
- **Completeness:** The completeness of the data is generally acceptable.
- **Sensitivity:** A small number of analytes required dilutions due to concentrations exceeding the calibration range of the instrument and a few other samples were analyzed at dilutions due to possible matrix interference. Several analytes still exceeded the calibration range at 10x dilutions due to the reasons described above.

The parameters that are discussed above were collected for the purpose of assessing ecological and human health risk assessment issues. Additionally, a number of groundwater samples were analyzed for a variety of geochemical parameters for the purpose of assessing remedial options during the feasibility study stage of the project. A discussion of the data validation issues associated with these samples is presented below.

4.2.7 Metals By Method 6010B and Mercury By Method 7470/SW7471

No "R" flags are observed in the metals data although matrix effects did impact some results.

In summary:

- **Precision:** The precision of these data is generally acceptable.
- **Accuracy:** The accuracy of some data may display a greater than usual bias due to possible matrix effect. These results should be used knowing that possible matrix effect may have caused a greater than normal bias in the sample results.
- **Representativeness:** The representativeness of the data is generally acceptable.
- **Completeness:** The completeness for these data is generally acceptable.
- **Sensitivity:** A small number of analytes required dilutions due to concentrations exceeding the calibration range of the instrument and a few other samples were analyzed at dilutions due to possible matrix interference.

SECTIONFIVE Remedial Investigation Results

As summarized in Section 3 of this document, investigations have been conducted at SA2 Sites O, P, Q, R, and S. A discussion of the SA2 investigation results summarized within this section include: disposal area identification, waste characterization, hydrogeology investigation, subsurface and surface soil sampling, air sampling, seep sampling, slug testing, and quality assurance. Only results which have been validated as discussed in Section 4, are discussed. Dioxin values were converted to a total dioxin TEQ (equivalent to 2,3,7,8-TCDD) value. The TEQ value was calculated by applying the dioxin TEF to each detected cogener in a sample and summing the values. The discussion of the analytical results provided below is based on the total concentration of constituents in a particular suite (i.e., total VOCs, SVOCs, etc.). Environmental samples were analyzed for:

- VOCs (EPA Method 8260 (soil, water, and waste) and Method TO15(air))
- SVOCs (EPA Method 8270)
- Pesticides (EPA Method 8081)
- Herbicides (EPA Method 8151)
- PCBs (EPA Method 680)
- Dioxins (EPA Methods 8280A and 8290 (soil, water, and waste) and Method TO15 (air))
- Metals (EPA Method 6010) and Mercury (EPA Methods 7470/7471).

The discussion of the analytical results provided below is based on the total concentration of each constituent suite, except for metals. Total concentrations of a constituent suite were determined by summing the results of individual constituents within that suite. Results of constituents that were not detected above laboratory detection limits or from samples rejected during the data validation process were considered to be zero in this summation. The concentrations of constituents detected at estimated levels below the laboratory reporting limits were included at the estimated value in the summation of a constituent suite. Metals results were not summed and are discussed based on the results of four representative metals (copper, lead, mercury, and zinc) for the SA2 Site. These metals are considered representative of the area based on historic records and operations of facilities in the surrounding area. As discussed in Section 1.8, the Support Sampling Data Report (URS, 2003a), which included all the analytical data on a constituent-by-constituent basis, was submitted in April 2003.

5.1 DISPOSAL AREA IDENTIFICATION

The disposal area investigation was performed to assist in defining disposal area boundaries of individual sites (O, P, Q, R, S) located within the entire SA2 project area. Prior to field activities, a historic aerial photograph analysis was performed to verify the boundary of each site. Confirmatory boundary trench locations for each site were then located based on existing information, which included the historic aerial photo analysis. Disposal areas were further defined by conducting a magnetometer survey, a soil gas survey, and completing waste borings. In addition, anomaly trenches were completed at locations having a potential presence of buried metallic objects as identified in the magnetometer survey.

5.1.1 Magnetometer Survey

Magnetometer surveys were performed in Sites P, Q, R, and S as described in Section 3.2.1 of this report, to identify subsurface anomalies. A magnetometer survey was not conducted in Site O because site closure records indicated that no drums were present at this location. Magnetic anomalies, which are not associated with known surface materials, were further investigated for the potential presence of buried drums or tanks by the excavation of anomaly trenches as described in Section 3.2.3.2 of this report. Intact drums or tanks were not discovered during the excavation of the anomaly trenches at locations of magnetic anomalies identified during the magnetometer survey. Magnetic anomalies observed during the magnetometer survey are likely attributable to the presence of construction debris contain steel reinforcing bar, metallic construction debris, or drum remnants. A summary of magnetic anomalies observed which could not be explained by surface features (power line, parked vehicles, and surface debris) is summarized below. The results of the magnetometer surveys for each site are presented in Figures 5-1a through 5-1d.

Site P

Magnetic anomalies were distributed randomly throughout Site P. No pattern or correlation of the anomalies was apparent. The results of the magnetometer survey for Site P are presented in Figure 5-1a.

Site Q

Magnetic anomalies were distributed randomly throughout Site Q. A higher number of anomalies were identified in Site Q Central than in Site Q North or Site Q South. One large anomaly observed in Site Q North, along the eastern side is relative to an old abandoned railroad line. In addition, a significant number of the anomalies identified in the portion of the site bordering the Mississippi River could be attributed to surface features such as machines, buildings, and vehicles. The results of the magnetometer survey for Site Q are presented in Figure 5-1b.

Site R

The area with the greatest number of magnetic anomalies and the highest magnetic readings within Site R that could not be attributed to observed site conditions were located within the central portion of the Site. Areas of elevated readings outside the central portion of the site could be attributed to the presence of high voltage electrical line towers. The results of the magnetometer survey for Site R are presented in Figure 5-1c.

Site S

Magnetic anomalies in Site S appeared to be concentrated within the northern portion of the site. Several anomalies were also observed near the western boundary of the site. These anomalies appeared to be trending in a north-south direction and were all located approximately the same distance east of the western property boundary and may be attributable to a known utility corridor immediately west of Site S. The results of the magnetometer survey for Site S are presented in Figure 5-1d.

5.1.2 Soil Gas Survey

Soil gas samples were collected at 354 locations throughout the SA2 Sites and analyzed for total VOCs as described in Section 3.2.2 of this report. A summary of the total VOC analytical results for each Site is provided below. A summary of soil gas sampling analytical data is presented in Tables 5-1a through 5-1e for Sites O, P, Q, R, and S, respectively. The soil gas analytical results were used to verify the site boundaries and to place the waste borings. The analytical results indicated that the existing site boundaries adequately represented the disposal area. The soil gas analytical results provided information which allowed the waste boring locations to be positioned such that they were biased toward the more highly impacted waste material.

Site O

Soil gas samples were collected from 49 locations within Site O. Total VOC concentrations were detected in 16 of the 49 sampling locations at concentrations ranging from 5 ppb to 6,641 ppb.

Site P

Soil gas samples were collected from 29 locations within Site P. Total VOC concentrations were detected in 8 of the 29 sampling locations at concentrations ranging from 17 ppb to 547 ppb.

Site Q

Soil gas samples were collected from 232 locations within Site Q. Total VOC concentrations were detected in 68 of the 232 sampling locations at concentrations ranging from 1 ppb to 113 ppb.

Site R

Soil gas samples were collected from 33 locations within Site R. Total VOC concentrations were detected in 11 of the 33 sampling locations at concentrations ranging from 19 ppb to 25,231 ppb.

Site S

Soil gas samples were collected from 11 locations within Site S. Total VOC concentrations were detected in 7 of the 11 sampling locations at concentrations ranging from 2,804 ppb to 54,996 ppb.

5.1.3 Test Trenches

5.1.3.1 Boundary Trenches

A total of 24 boundary trenches were completed at the five sites in a manner described in Section 3.2.3.1 of this report. A summary of the findings and results of each boundary trench completed at each site are listed below. A summary table of boundary trenching activities is presented in Table 3-2.

Site O

Four boundary trenches (BT-O-01 to BT-O-04) were located in Site O and the waste material boundary was identified in all four trenches. The material encountered in each trench could be considered industrial waste, consisting of sludge materials consistent with historical information.

Site P

Four boundary trenches (BT-P-01 to BT-P-04) were located in Site P and the waste boundary was identified in BT-P-01 and BT-P-02. The material encountered in each trench could be considered municipal waste. A drum lid was observed in trench BT-P-03, which was terminated in waste material after being excavated the required length of 40 feet. Trench BT-P-04 was terminated in waste at the edge of Monsanto Avenue along the southern edge of Site P.

Site Q North

Five boundary trenches (BT-Q-01 to BT-Q-05) were located in Site Q North. Trenches BT-Q-02 and BT-Q-04 were co-located with Site R trenches BT-R-03 and BT-R-04, respectively. The waste boundary was identified in trench BT-Q-4, and the material encountered in each trench could be considered industrial waste. A white crystalline material was observed in trench BT-Q-04/BT-R-04 and drum remnants were observed in trench BT-Q-02/ BT-R-03. Trenches BT-Q-02/BT-R-03 and BT-Q-05 were excavated the required distance of 40 feet without locating the boundary of the waste material. Trenches BT-Q-01 and BT-Q-03 were terminated in waste material prior to being excavated the required distance of 40 feet due to the presence of a road.

Site Q Central

One boundary trench (BT-Q-06) was located in Site Q Central and the waste boundary was not identified in this trench. Trench BT-Q-06 could not be excavated the required 40-foot distance due to the presence of mulch piles and a pond.

Site Q South

Four boundary trenches (BT-Q-07 to BT-Q-10) were located in Site Q South and the waste boundary was identified in trenches BT-Q-08 and BT-Q-09. Drum remnants were observed in trench BT-Q-07. Trenches BT-Q–07 and BT-Q-10 were excavated the required distance of 40 feet without locating the boundary of the waste material.

Site R

Four boundary trenches (BT-R-01 to BT-R-04) were located in Site R. Trenches BT-R-03 and BT-R-04 were co-located with Site Q trenches BT-Q-02 and BT-Q-04, respectively. The waste boundary was identified in BT-R-02 and BT-R-04. Trench BT-R-01 was terminated in waste at the edge of Riverview Avenue along the northern edge of Site R due to significant utilities under Riverview Avenue and trench BT-R-03 was terminated in waste material after being excavated the required length of 40 feet. The material encountered within each trench could be considered industrial waste, consisting of white crystalline material and cinders. Drum remnants were observed in trenches BT-R-02 and BT-R-03.

Site S

Four boundary trenches (BT-S-01 to BT-S-04) were completed in Site S and the waste boundary was identified in trenches BT-S-01, BT-S-03, and BT-S-04. Trench BT-S-02 was terminated in waste material due to a utility corridor along the western edge of Site S. The material encountered in each trench could be considered industrial waste, which included drum remnants in trenches BT-S-01, BT-S-02, and BT-S-04 and NAPL in trench BT-S-02.

5.1.3.2 Anomaly Trenches

A total of 11 anomaly trenches were completed at Sites P, Q, R, and S in a manner described in Section 3.2.3.2 of this report. Trench locations were determined based on the potential presence of underground metallic objects identified during the magnetometer survey. Prior to excavation of each anomaly trench, the location was discussed with and approved by the USEPA Region V representative (CH2MHill). Although the investigation targeted potential underground anomalies, no large buried tanks or intact drums were located. Anomalies were likely attributable to the presence of construction debris containing steel reinforcing bar, metallic construction debris, or drum remnants. A summary of the findings and results of each anomaly trench completed at each Site is listed below. A summary table of anomaly trenching activities is presented in Table 3-2.

Site O

No anomaly trenches were located in Site O as part of this investigation. Anomaly trenches were not completed because site closure records indicated that there were no drums present at this site.

Site P

One anomaly trench (AT-P-01) was located in Site P. Drum remnants and construction debris were observed in this anomaly trench.

Site Q North

One anomaly trench location (AT-Q-11) was within Site Q North. Evidence of industrial waste within Site Q trenches included fiber drum remnants in trench AT-Q-11. Construction debris or municipal waste was observed in all other anomaly trenches completed within Site Q North.

Site Q Central

Five anomaly trenches (AT-Q-12 to AT-Q-16) were located within Site Q Central. Construction debris, municipal waste, and a drum lid (AT-Q-15) was observed in the anomaly trenches completed within Site Q Central

Site Q South

Two anomaly trenches (AT-Q-17 and AT-Q-18) were located within Site Q South. Construction debris, municipal waste, and a steel tank approximately 3 feet by 5 feet was observed in AT-Q-16. Anomaly trench AT-Q-17 could not be excavated due to the presence of an approximately 30-foot high stockpile of fill material at the proposed trench location.

Site R

One anomaly trench (AT-R-01) was located in Site R. Drum remnants and construction debris were observed in this anomaly trench.

Site S

One anomaly trench (AT-S-01) was located in Site S. Drum remnants, NAPL and construction debris were observed in this anomaly trench. The NAPL was observed by URS oversight personnel, however, in accordance with the work plan no effort was made to determine nature and extent due to health and safety concerns per OSHA regulations.

5.2 WASTE CHARACTERIZATION

5.2.1 Waste Samples

Twenty-five waste samples were collected from the SA2 project area as described in Section 3.3.1 of this report. For the purpose of discussing the results, samples are divided into groups of discrete subsurface and composite subsurface samples. A summary of waste analytical data is presented in Table 5-2 and Figures 5-2a through 5-2j.

Discrete Subsurface Waste Samples

Twenty-five discrete subsurface waste samples were collected within the SA2 project area and analyzed for VOCs and dioxins (both total and TCLP extract). The detected total concentration ranges for each constituent suite are provided below.

- VOCs were detected in all 25 samples with total VOC concentrations ranging from 2 µg/kg to 18,484,000 µg/kg
- Total dioxin TEQs were detected in 24 of the 25 samples with values ranging from 0.002 µg/kg to 497 µg/kg.

Composite Subsurface Waste Samples

Twenty-five composite subsurface waste samples were collected within the SA2 project area and analyzed for SVOCs, pesticides, herbicides, PCBs and metals (both total and TCLP extract). For the metals analysis discussion, four metals were selected, based on their presence and concentrations representative of this class of constituents. These four metals were copper, lead, mercury and zinc. The detected total concentration ranges for each constituent suite are provided below.

- SVOCs were detected in all 25 samples with total SVOC concentrations ranging from 1,944 µg/kg to 5,807,000 µg/kg.
- Pesticides were detected in all 25 samples with total pesticide concentrations ranging from 39 µg/kg to 62,670 µg/kg.
- Herbicides were detected in 22 of the 25 samples with total herbicide concentrations ranging from 15 µg/kg to 619,000 µg/kg.

- PCBs were detected in 23 of the 25 samples with total PCB concentrations ranging from 11 µg/kg to 1,618,100 µg/kg.
- Copper was detected in all 25 samples at concentrations ranging from 8 mg/kg to 4,600 mg/kg.
- Lead was detected in all 25 samples at concentrations ranging from 8 mg/kg to 2,600 mg/kg.
- Mercury was detected in all 25 samples at concentrations ranging from 0.07 mg/kg to 3,000 mg/kg.
- Zinc was detected in all 25 samples at concentrations ranging from 30 mg/kg to 6,400 mg/kg.

5.2.2 Leachate Wells

5.2.2.1 Quarterly Sampling

Nine leachate samples were collected during four quarterly sampling events performed in September 2002, February, April, and June 2003. Leachate samples were collected from three locations (Leach-O-1, Leach-Q-1, and Leach-R-1) in September 2002 and two locations (Leach-Q-1 and Leach-R-1) during the remaining three quarterly sampling events. Samples could not be obtained from the remaining leachate wells (Leach-P-1, Leach-Q-2, Leach-Q-3, and Leach-S-1) or Leach-O-1 in February, April, and June 2003 due to insufficient leachate present in the wells.

The samples collected during these quarterly sampling events contained detectable concentrations of VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals above the corresponding laboratory detection limits. The detected concentration ranges for each constituent suite are provided below. A summary of the leachate analytical data is presented in Table 5-3a through 5-3d and Figures 5-4a through 5-4j.

- VOCs were detected in all 9 samples with total VOC concentrations ranging from 5,131 µg/l to 206,734,000 µg/l.
- SVOCs were detected in all 9 samples with total SVOC concentrations ranging from 11,766 µg/l to 9,713,800 µg/l.
- Pesticides were detected in 5 of the 9 samples with total pesticide concentrations ranging from 3 µg/l to 1,160 µg/l.

- Herbicides were detected in 8 of the 9 samples with total herbicide concentrations ranging from 1,910 µg/l to 1,419,130 µg/l.
- PCBs were detected in 8 of the 9 samples with total PCB concentrations ranging from 0.5 µg/l to 453,400 µg/l.
- Total dioxin TEQs were detected in 8 of the 9 samples with values ranging from 0.000000024 µg/l to 0.0031 µg/l.
- Copper was detected in 6 of the 9 samples at concentrations ranging from 0.01 mg/l to 7 mg/l.
- Lead was detected in 5 of the 9 samples at concentrations ranging from 0.005 mg/l to 3 mg/l.
- Mercury was detected in 6 of the 9 samples at concentrations ranging from 0.001 mg/l to 0.03 mg/l.
- Zinc was detected in all 9 samples at concentrations ranging from 0.2 mg/l to 130 mg/l.

5.3 HYDROGEOLOGY

5.3.1 Alluvial Aquifer

Alluvial Aquifer

A total of 227 groundwater samples were collected from 22 alluvial aquifer sampling locations. Every sample was analyzed for VOCs and SVOCs, and 82 of these samples were further analyzed for pesticides, herbicides, PCBs, and metals, while 24 were also analyzed for dioxins. No constituent concentrations were detected above the corresponding laboratory detection limit for mercury or dioxins. A summary of the alluvial aquifer analytical data is presented in Tables 5-4 and 5-5a and Figures 5-5a through 5-5j.

Upgradient

A total of 44 groundwater samples were collected from 4 upgradient sample locations (GW-UAA-1 through GW-UAA-4). Each sample collected was analyzed for VOCs and SVOCs, and 16 samples were further analyzed for pesticides, herbicides, PCBs, and metals. Six of the samples were also analyzed for dioxins. Constituent concentrations were detected above the corresponding laboratory detection limits for VOCs, SVOCs, pesticides, herbicides, PCBs,

copper, lead, and zinc (metals analyses were for unfiltered samples). No constituent concentrations were detected above the corresponding laboratory detection limit for mercury or dioxins. The detected concentration ranges for the each constituent suite are provided below:

- VOCs were detected in 37 of the 44 samples with total VOC concentrations ranging from 0.4 µg/l to 2,739 µg/l.
- SVOCs were detected in 18 of the 44 samples with total SVOC concentrations ranging from 5 µg/l to 4,438 µg/l.
- Pesticides were detected in 7 of the 16 samples with total pesticide concentrations ranging from 0.01 µg/l to 0.2 µg/l.
- Herbicides were detected in 6 of the 16 samples with total herbicide concentrations ranging from 0.05 µg/l to 87 µg/l.
- PCBs were detected in 3 of the 16 samples with total PCB concentrations ranging from 0.04 µg/l to 0.08 µg/l.
- Copper was detected in 8 of the 16 samples at concentrations ranging from 0.002 mg/l to 0.09 mg/l.
- Lead was detected in 5 of the 16 samples at concentrations ranging from 0.003 mg/l to 0.02 mg/l.
- Zinc was detected in 14 of the 16 samples at concentrations ranging from 0.009 mg/l to 300 mg/l.

Site O

A total of 36 groundwater samples were collected from 3 sample locations (GW-AA-O-1 through GW-AA-O-3). Each sample collected was analyzed for VOCs and SVOCs and 12 samples were further analyzed for pesticides, herbicides, PCBs, and metals. Three of the samples were also analyzed for dioxins. Constituent concentrations were detected above the corresponding laboratory detection limits for VOCs, SVOCs, pesticides, herbicides, PCBs, copper, lead, mercury and zinc. No constituent concentrations were detected above the corresponding laboratory detection limit for dioxins. The detected concentration ranges for the each constituent suite are provided below:

- VOCs were detected in 34 of the 36 samples with total VOC concentrations ranging from 0.5 µg/l to 1,500 µg/l.
- SVOCs were detected in 23 of the 36 samples with total SVOC concentrations ranging from 1 µg/l to 122 µg/l.
- Pesticides were detected in 8 of the 12 samples with total pesticide concentrations ranging from 0.009 µg/l to 0.2 µg/l.
- Herbicides were detected in 7 of the 12 samples with total herbicide concentrations ranging from 0.09 µg/l to 4 µg/l.
- PCBs were detected in 2 of the 12 samples with total PCB concentrations ranging from 0.08 µg/l to 0.09 µg/l.
- Copper was detected in 3 of the 12 samples at concentrations ranging from 0.004 mg/l to 0.1 mg/l.
- Lead was detected in 5 of the 12 samples at concentrations ranging from 0.004 mg/l to 0.06 mg/l.
- Mercury was detected in 2 of the 12 samples at concentrations ranging from 0.0001 mg/l to 0.00008 mg/l.
- Zinc was detected in all of the 12 samples at concentrations ranging from 0.008 mg/l to 0.4 mg/l.

Site P

A total of 33 groundwater samples were collected from 3 sample locations (GW-AA-P-1 through GW-AA-P-3). Each sample collected was analyzed for VOCs and SVOCs and 12 samples were analyzed for pesticides, herbicides, PCBs, and metals. Three of the samples were also analyzed for dioxins. Constituent concentrations were detected above the corresponding laboratory detection limits for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, copper, lead, mercury and zinc. The detected concentration ranges for the each constituent suite are provided below:

- VOCs were detected in 28 of the 33 samples with total VOC concentrations ranging from 0.3 µg/l to 7,632 µg/l.

- SVOCs were detected in 9 of the 33 samples with total SVOC concentrations ranging from 6 µg/l to 285 µg/l.
- Pesticides were detected in 4 of the 12 samples with total pesticide concentrations ranging from 0.004 µg/l to 0.01 µg/l.
- Herbicides were detected in 6 of the 12 samples with total herbicide concentrations ranging from 0.6 µg/l to 32 µg/l.
- PCBs were detected in 4 of the 12 samples with total PCB concentrations ranging from 0.11 µg/l to 0.14 µg/l.
- Total dioxin TEQs were detected in 2 of the 3 samples with values ranging from 0.0000007 µg/l to 0.00001 µg/l.
- Copper was detected in 8 of the 12 samples at concentrations ranging from 0.002 mg/l to 0.1 mg/l.
- Lead was detected in 4 of the 12 samples at concentrations ranging from 0.004 mg/l to 0.09 mg/l.
- Mercury was detected in 2 of the 12 samples at concentrations ranging from 0.00007 mg/l to 0.0002 mg/l.
- Zinc was detected in all of the 12 samples at concentrations ranging from 0.003 mg/l to 0.4 mg/l.

Site Q

A total of 68 groundwater samples were collected from 8 sample locations (GW-AA-Q-1 through GW-AA-Q-8). Each sample collected was analyzed for VOCs and SVOCs and 28 samples were further analyzed for pesticides, herbicides, PCBs, and metals. Six of the samples were also analyzed for dioxins. Constituent concentrations were detected above the corresponding laboratory detection limits for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, copper, lead, mercury, and zinc. The detected concentration ranges for the each constituent suite are provided below:

- VOCs were detected in 67 of the 68 samples with total VOC concentrations ranging from 1 µg/l to 12,052 µg/l.

- SVOCs were detected in 51 of the 68 samples with total SVOC concentrations ranging from 1 µg/l to 2,959 µg/l.
- Pesticides were detected in 14 of the 28 samples with total pesticide concentrations ranging from 0.008 µg/l to 0.1 µg/l.
- Herbicides were detected in 13 of the 28 samples with total herbicide concentrations ranging from 0.2 µg/l to 33 µg/l.
- PCBs were detected in 1 of the 28 samples with total PCB concentration of 0.3 µg/l.
- Total dioxin TEQs were detected in 2 of the 6 samples with values of 0.00000002 µg/l and 0.0000005 µg/l.
- Copper was detected in 23 of the 28 samples at concentrations ranging from 0.003 mg/l to 0.2 mg/l.
- Lead was detected in 23 of the 28 samples at concentrations ranging from 0.003 mg/l to 0.2 mg/l.
- Mercury was detected in 9 of the 28 samples at concentrations ranging from 0.00008 mg/l to 0.0005 mg/l.
- Zinc was detected in 25 of the 28 samples at concentrations ranging from 0.008 mg/l to 1 mg/l.

Site R

A total of 11 groundwater samples were collected from 1 sample location (GW-AA-R-1). Each sample collected was analyzed for VOCs and SVOCs and 3 samples were further analyzed for pesticides, herbicides, PCBs, dioxins, and metals. Constituent concentrations were detected above the corresponding laboratory detection limits for VOCs, SVOCs, pesticides, herbicides, dioxins, copper, lead, mercury, and zinc. No constituent concentrations were detected above the corresponding laboratory detection limit for PCBs. The detected concentration ranges for the each constituent suite are provided below:

- VOCs were detected in all of the 11 samples with total VOC concentrations ranging from 1,899 µg/l to 106,250 µg/l.

- SVOCs were detected in all of the 11 samples with total SVOC concentrations ranging from 1,960 µg/l to 123,147 µg/l.
- Pesticides were detected in all of the 3 samples with total pesticides concentrations ranging from 0.6 µg/l to 2 µg/l.
- Herbicides were detected in all of the 3 samples with total herbicides concentrations ranging from 51 µg/l to 200 µg/l.
- Total dioxin TEQs were detected in 1 of the 3 samples with a value of 0.00000002 µg/l.
- Copper was detected in all of the 3 samples at concentrations ranging from 0.07 mg/l to 0.1 mg/l.
- Lead was detected in all of the 3 samples at concentrations ranging from 0.02 mg/l to 0.04 mg/l.
- Mercury was detected in 1 of the 3 samples at a concentration of 0.0001 mg/l.
- Zinc was detected in all of the 3 samples at concentrations ranging from 0.2 mg/l to 0.4 mg/l.

Site S

A total of 34 groundwater samples were collected from 3 sample locations (GW-AA-S-1 through GW-AA-S-3). Each sample collected was analyzed for VOCs and SVOCs and 11 samples were further analyzed for pesticides, herbicides, PCBs, and metals. Three of the samples were also analyzed for dioxins. Constituent concentrations were detected above the corresponding laboratory detection limits for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, copper, lead, and zinc. No constituent concentrations were detected above the corresponding laboratory detection limit for Mercury. The detected concentration ranges for the each constituent suite are provided below:

- VOCs were detected in 30 of the 34 samples with total VOC concentrations ranging from 0.3 µg/l to 531 µg/l.
- SVOCs were detected in 14 of the 34 samples with total SVOC concentrations ranging from 0.9 µg/l to 19 µg/l.

- Pesticides were detected in 5 of the 11 samples with total pesticides concentrations ranging from 0.01 µg/l to 0.1 µg/l.
- Herbicides were detected in 2 of the 11 samples with total herbicides concentrations of 0.099µg/l and 0.12 µg/l.
- PCBs were detected in 3 of the 11 samples with total PCB concentrations ranging from 0.04 µg/l to 0.1 µg/l.
- Total dioxin TEQs were detected in 1 of the 3 samples with a value of 0.000000006 µg/l.
- Copper was detected in 3 of the 11 samples at concentrations ranging from 0.02 mg/l to 0.06 mg/l.
- Lead was detected in 6 of the 11 samples at concentrations ranging from 0.003 mg/l to 0.02 mg/l.
- Zinc was detected in 8 of the 11 samples at concentrations ranging from 0.009 mg/l to 0.2 mg/l.

5.3.2 Bedrock Wells

5.3.2.1 Quarterly Sampling

Twenty-four bedrock groundwater samples were collected during four quarterly sampling events performed during September 2002, February, April, and June 2003. During these four quarterly sampling events, bedrock groundwater samples were collected from six locations (Bdrk-O-1, Bdrk-P-1, Bdrk-Q-1, Bdrk-Q-2, Bdrk-R-1, and Bdrk-S-1). The samples collected during these quarterly sampling events contained detectable concentrations of total VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals. No constituent concentrations were detected above the corresponding laboratory detection limit for PCBs. The detected concentration ranges for each constituent suite are discussed below. A summary of the bedrock aquifer analytical data is presented in Tables 5-3a through 5-3d, Table 5-5b and Figures 5-4a through 5-4j.

- VOCs were detected in 18 of the 24 samples with total VOC concentrations ranging from 0.3 µg/l to 89 µg/l .
- SVOCs were detected in 12 of the 24 samples with total SVOC concentrations ranging from 1 µg/l to 1,622 µg/l.

- Pesticides were detected in 2 of the 24 samples with total pesticide concentrations of 0.006 µg/l and 0.04 µg/l.
- Herbicides were detected in 8 of the 24 samples with total herbicides concentrations ranging from 0.1 µg/l to 89 µg/l.
- Total dioxin TEQs were detected in 1 of the 24 samples with a value of 0.000000006 µg/l.
- Copper was detected in 14 of the 24 samples at concentrations ranging from 0.001 mg/l to 0.06 mg/l.
- Lead was detected in 7 of the 24 samples at concentrations ranging from 0.003 mg/l to 0.03 mg/l.
- Mercury was detected in 8 of the 24 samples at concentrations ranging from 0.00007 mg/l to 0.0002 mg/l.
- Zinc was detected in 21 of the 24 samples at concentrations ranging from 0.002 mg/l to 0.2 mg/l.

5.3.2.2 Thin Section Analysis

Petrographic thin-section analysis for porosity of 54 bedrock samples was performed as described Section 3.4.2.4 of this report. The thin-section analysis was completed by Omni Laboratories and the results are presented in the report entitled "Porosity Types Study Involving Thin Section Modal Analysis of Conventional Core Samples" which is included as Appendix I. The petrographic thin-section analysis indicates that all 54 samples are carbonate rocks. Fifty of the samples are identified as limestones, three are categorized as dolostones, and one is chert. Overall, porosity of the entire sample suite averages 3% (by volume). By rock type this corresponds to 24% (by volume) in the chert, 20% (by volume) in the dolostones, and 2% (by volume) in the limestones.

A summary table of the thin-section analysis is presented in Table 5-6.

5.3.2.3 Piezometers – Geotechnical Sampling

A total of 30 geotechnical samples were collected from the three hydrologic units at the nine piezometer locations as described in Section 3.4.3 of this report. The samples were analyzed by

the URS geotechnical laboratory in Totowa, New Jersey for the parameters specified in Section 3.4.3.2. Unified Soil Classification Standards classifications made by the laboratory of the 30 samples indicated that 17 were classified as a poorly graded sand (SP), three were classified as silty sand (SM), two were classified as a well graded sand to silty sand (SW-SM), two were classified as a poorly graded sand to silty sand (SP-SM), and one sample each was classified as well graded sand (SW), clayey sand (SC), clay (CL), silt (ML), clayey gravel (GC) and poorly graded gravel (GP). Additional geotechnical laboratory results of the samples indicate the following:

- Water Content of discrete depths from within each sample tube ranged from 4.2% to 37.7%
- Quantity of soil passing a No. 200 sieve ranged from 0.1% to 94.0%
- Organic content ranged from 0.1% to 2.7%
- pH (distilled water) ranged from 6.4 to 9.5
- pH (0.01 M CaCl Solution) ranged from 6.2 to 8.6
- Total unit weight ranged from 107.0 pounds per cubic foot (pcf) to 147.5 pcf
- Dry unit weight ranged from 91.6 pcf to 137.5 pcf
- Specific gravity ranged from 2.627 to 2.729
- Total porosity ranged from 17.8% to 45.1%
- Water filled soil porosity ranged from 13.2% to 45%
- Air filled soil porosity ranged from –3.7% to 20.4%. The negative value is a result of variations in the tube and measurement errors and are indicative of saturated material.

A summary of the geotechnical laboratory results is presented in Table 5-7 and in Appendix J.

5.4 SURFACE AND SUBSURFACE SOIL SAMPLING

A total of 38 discrete surface and 30 discrete subsurface soil samples were collected from the SA2 project area as described in Section 3.5 of this report. The results of this analysis are presented below.

Discrete Surface Soil Samples

Thirty-eight discrete surface soil samples were collected at off-site and on-site locations and analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals. The detected concentrations ranges for each constituent suite are provided below. A summary of the surface soil sample analytical data is presented in Table 5-8 and Figures 5-6a through 5-6j.

- VOCs were detected in 33 of the 38 samples with total VOC concentrations ranging from 2 µg/kg to 92,130 µg/kg.
- SVOCs were detected in 34 of 38 samples with total SVOC concentrations ranging from 20 µg/kg to 392,200 µg/kg.
- Pesticides were detected in 35 of the 38 samples with total pesticide concentrations ranging from 0.4 µg/kg to 74,840 µg/kg.
- Herbicides were detected in 36 of the 38 samples with total herbicide concentrations ranging from 3.3 µg/kg to 443,550 µg/kg.
- PCBs were detected in 29 of the 38 samples with total PCB concentrations ranging from 0.8 µg/kg to 1,008,500 µg/kg.
- Total dioxin TEQs were detected in 30 of the 38 samples with values ranging from 0.0003 µg/kg to 51 µg/kg.
- Copper was detected in all 38 samples at concentrations ranging from 7 mg/kg to 2,600 mg/kg.
- Lead was detected in 37 of the 38 samples at concentrations ranging from 9 mg/kg to 3,100 mg/kg.
- Mercury was detected in 37 of the 38 samples at concentrations ranging from 0.02 mg/kg to 43 mg/kg.
- Zinc was detected in all 38 samples at concentrations ranging from 43 mg/kg to 8,000 mg/kg.

Discrete Subsurface Soil Samples

Thirty discrete subsurface soil samples were collected at off-site and on-site locations and analyzed for VOCs, SVOCs, pesticides, herbicides PCBs, dioxins, and metals. The detected concentrations ranges for each constituent suite are provided below. A summary of the subsurface soil sample analytical data is presented in Table 5-9 and Figures 5-7a through 5-7j.

- VOCs were detected in 28 of the 30 samples with total VOC concentrations ranging from 2 µg/kg to 5,673,000 µg/kg.
- SVOCs were detected in 22 of the 30 samples with total SVOC concentrations ranging from 30 µg/kg to 2,884,000 µg /kg.
- Pesticides were detected in 27 of the 30 samples with total pesticide concentrations ranging from 0.5 µg/kg to 211,500 µg/kg.
- Herbicides were detected in 24 of the 30 samples with total herbicide concentrations ranging from 2 µg/kg to 680,000 µg/kg.
- PCBs were detected in 21 of the 30 samples with total PCB concentrations ranging from 1 µg/kg to 3,026,000 µg/kg.
- Total dioxin TEQs were detected in 21 of the 30 samples with values ranging from 0.0002 µg/kg to 428 µg/kg.
- Copper was detected in all of the 30 samples at concentrations ranging from 3 mg/kg to 20,000 mg/kg.
- Lead was detected in all 30 samples at concentrations ranging from 4 mg/kg to 24,000 mg/kg.
- Mercury was detected in all 30 of the samples at concentrations ranging from 0.005 mg/kg to 360 mg/kg.
- Zinc was detected in all 30 off the samples at concentrations ranging from 19 mg/kg to 11,000 mg/kg.

5.5 AIR SAMPLING

Sixteen ambient air samples (8 upwind and 8 downwind) were collected from four sites within the SA2 project area described in Section 3.6 of this report. The samples collected contained detectable concentrations of VOCs, SVOCs, pesticides, PCBs, dioxins, and metals. The detected concentrations ranges for each constituent suite are provided below. A summary for air sample analytical data is presented in Table 5-10 and Figures 5-8a through 5-8h.

- VOCs were detected in all 16 of the samples with total VOC concentrations ranging from 14 $\mu g/m^3$ to 71 $\mu g/m^3$.
- SVOCs were detected in all 16 of the samples with total SVOC concentrations ranging from 0.03 $\mu g/m^3$ to 0.3 $\mu g/m^3$.
- Pesticides were detected in 12 of the 16 samples with total pesticide concentrations ranging from 0.00008 $\mu g/m^3$ to 0.0004 $\mu g/m^3$.
- PCBs were detected in 12 of the 16 samples with total PCB concentrations ranging from 0.0002 $\mu g/m^3$ to 0.009 $\mu g/m^3$.
- Total dioxin TEQs were detected in all 16 of the samples with values ranging from 0.00006 pg/m^3 to 0.01 pg/m^3.
- Copper was detected in 3 of the 16 samples at concentrations ranging from 0.05 $\mu g/m^3$ to 0.06 $\mu g/m^3$.
- Lead was detected in 8 of the 16 samples at concentrations ranging from 0.01 $\mu g/m^3$ to 0.02 $\mu g/m^3$.
- Zinc was detected in 4 of the 16 samples at concentrations ranging from 0.05 $\mu g/m^3$ to 0.06 $\mu g/m^3$.

5.6 STORMWATER SAMPLING

Stormwater samples were collected at two locations in Site Q (Storm-Q-1 and Storm-Q-2) and one location in Site R (Storm-R-1) during two different rainfall events, which occurred on September 18, 2002 and October 3, 2002. The samples collected during these two rainfall events contained detectable concentrations of total VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals. The detected concentration ranges for each constituent suite are provided

below. A summary of the stormwater sampling analytical data is presented in Table 5-11 and Figures 5-14a through 5-14ad.

- VOCs were detected in all 6 samples with total VOC concentrations ranging from 30 µg/l to 60 µg/l.
- SVOCs were detected in 4 of the 6 samples with total SVOC concentrations ranging from 1 µg/l to 5 µg/l.
- Pesticides were detected in all 6 of the samples with total pesticide concentrations ranging from 0.01 µg/l to 0.1 µg/l.
- Herbicides were detected in 4 of the 6 samples with total herbicide concentrations ranging from 1 µg/l to 401 µg/l.
- PCBs were detected in 1 of the 6 samples with a total PCB concentration of 0.032 µg/l.
- Total dioxin TEQs were detected in all 6 samples with values ranging from 0.0000001 µg/l to 0.00002 µg/l.
- Copper was detected in 5 of the 6 samples at concentrations ranging from 0.001 mg/l to 0.02 mg/l.
- Lead was detected in 5 of the 6 samples at concentrations ranging from 0.005 mg/L to 0.02 mg/L.
- Mercury was detected in 5 of the 6 samples at concentrations ranging from 0.002 mg/l to 0.0004 mg/l.
- Zinc was detected in all 6 samples at concentrations ranging from 0.05 mg/l to 0.2 mg/l.

5.7 SEEP SAMPLING

Seep samples were collected from three locations within the SA2 project area as described in Section 3.8 of this report. The samples collected from these locations contained detectable concentrations of total VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins and metals. The detected concentration ranges for each constituent suite are provided below. A summary of the seep sampling analytical data is presented in Table 5-12 and Figures 5-3a through 5-3j.

- VOCs were detected in 2 of the 3 samples with total VOC concentrations of 11 µg/l and 963 µg/l.
- SVOCs were detected in 1 of the 3 samples with a total SVOC concentration of 7,289 µg/l.
- Pesticides were detected in 2 of the 3 samples with total pesticide concentrations of 0.05 µg/l and 1 µg/l.
- Herbicides were detected in 1 of the 3 samples with a total herbicide concentration of 172 µg/l.
- PCBs were detected in 1 of the 3 samples with a total PCB concentration of 0.2 µg/l.
- Total Dioxin TEQs were detected in 1 of the 3 samples with a value of 0.0001 µg/l.
- Copper was detected in all 3 of the samples at concentrations ranging from 0.01 mg/l to 0.4 mg/l.
- Lead was detected in all 3 of the samples at concentrations ranging from 0.01 mg/l to 0.3 mg/l.
- Mercury was detected in 1 of the 3 samples at a concentration of 0.0009 mg/l.
- Zinc was detected in all 3 samples at concentrations ranging from 0.06 mg/l to 2 mg/l.

5.8 SLUG TESTING

Slug testing was performed on bedrock wells and piezometers completed in the SHU, MHU, and DHU as described in Section 3.9 of this report. The slug test data was evaluated using the unconfined solution in the Bouwer and Rice method run by AQTESOLV® version 2.5. The Bouwer and Rice method considers the effect of partial penetration, the radius of the filter pack, and the effective radius of influence of the test. A summary of the rising and falling head slug tests performed in bedrock wells and piezometers is discussed below. A summary of the slug testing results is presented in Tables 5-13a through 5-13d. The slug test reduction forms are presented in Appendix K.

Shallow Hydrogeologic Unit Piezometers

Slug tests were performed in 5 of the 9 piezometers screened in the SHU. Slug tests were not performed on shallow piezometers Piez-1 (SHALLOW), Piez-2 (SHALLOW), Piez-4 (SHALLOW), and Piez-7 (SHALLOW) due to absence of groundwater within the screened interval of the piezometers. Data collected during the falling head test in Piez-5-SHALLOW was not included in this report because the groundwater elevation in the piezometer was below the top of screen at the time the falling head test was performed. Falling head tests produce unreliable data in wells in which the well screen is not fully saturated, since displaced water is allowed to escape through the unsaturated well screen.

Hydraulic conductivities of the SHU for both rising and falling head tests were calculated to be from 1.3×10^{-4} cm/sec to 1.7×10^{-2} cm/sec. The average hydraulic conductivity, including both rising and falling head tests for the five shallow piezometers tested was calculated to be 5.4×10^{-3} cm/sec.

Middle Hydrogeologic Unit Piezometers

Slug tests were performed in all nine of the piezometers screened in the MHU. However, data collected from middle piezometer Piez-9 (MIDDLE) was determined that erroneous (data logger error) and this data was not used in the subsequent data reduction efforts. Hydraulic conductivities of the MHU for both rising and falling head tests were calculated to range from 2.4×10^{-2} cm/sec to 8.7×10^{-2} cm/sec. The average hydraulic conductivity, including both rising and falling head tests for the eight middle piezometers tested, is 3.9×10^{-2} cm/sec.

Deep Hydrogeologic Unit Piezometers

Hydraulic conductivities of the DHU for both rising and falling head tests were calculated to be range from 8.8×10^{-3} cm/sec to 8.9×10^{-2} cm/sec. The average hydraulic conductivity, including both rising and falling head tests for the nine deep piezometers tested, was calculated to be 2.4×10^{-2} cm/sec.

Bedrock Wells

Slug tests were performed in all six bedrock wells, however, data collected from bedrock wells Bdrk-P-1 and Bdrk-R-1 was not reduced by the AQTESOLV® program due to variable groundwater elevations. The recharge rates of both wells was extremely slow, which allowed the

water levels in both wells to fluctuate naturally in response to precipitation and changes in atmospheric pressure and river stage during the course of the test.

Hydraulic conductivities of the four bedrock, in which data was reduced by AQTESOLV®, wells for both rising and falling head tests ranged from 2.5 x 10^{-4} cm/sec to 1.4 x 10^{-2} cm/sec. The average hydraulic conductivity, including both rising and falling head tests for the four bedrock wells tested, was calculated to be 4.1 x 10^{-3}.

5.9 GROUNDWATER ELEVATIONS

Prior to each quarterly groundwater monitoring event, the water elevations in each piezometer, bedrock well and leachate well were measured from the TOC to the nearest 1/100th of a foot using a petroleum/water interface probe. The total depth of the well from the TOC was also measured at this time. Water level measurements, the total well depth, and the screened intervals for each piezometer or monitoring well are summarized in Table 3-5.

Based on groundwater elevations, the groundwater flow direction in the shallow, medium, and deep hydrogeologic units was generally to the west for each quarterly event. The groundwater elevations measured in the piezometers were used to generate groundwater elevation contour maps for the shallow, medium, and deep hydrogeologic units for each quarterly event. The groundwater elevation contour maps are presented in Figures 5-9 through 5-12.

5.10 SURFACE WATER AND SEDIMENT SAMPLING

5.10.1 Mississippi River Sampling

A total of 41 discrete sediment and 43 discrete surface water samples were collected from the Mississippi River. Sediment samples were not collected at three proposed locations (R5AD, R5BD, and R6BD) due to the presence of rocks on the river bottom. These rocks also prevented the safe anchoring of the boat and thus the safe collection of a water sample at location R6BD. Each sample collected was analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, and metals and seven sediment and seven surface water samples were also analyzed for dioxins. The detected concentration ranges for each constituent suite are provided below.

Mississippi River Sediment

A summary of the river sediment analytical data is presented in Table 5-14 and Figures 5-13a through 5-13ad.

- VOCs were detected in 40 of the 41 samples with total VOC concentrations ranging from 3 µg/kg to 11,061 µg/kg.
- SVOCs were detected in 13 of the 40 valid samples with total SVOC concentrations ranging from 26 µg/kg to 3,298 µg/kg. One (R2BM1S) of the 41 samples collected was considered invalid during the validation process and therefore was omitted from the discussion of results.
- Pesticides were detected in 21 of the 41 samples with total pesticide concentrations ranging from 0.5 µg/kg to 30 µg/kg.
- Herbicides were detected in 15 of the 38 samples with total herbicide concentrations ranging from 1 µg/kg to 2,888 µg/kg. Results of three (R1AM1S, R1BD1S, and R2BU1S) of the 41 samples collected were considered invalid during the data validation process and therefore omitted from the discussion of results.
- PCBs were detected in 5 of the 41 samples with total PCB concentrations ranging from 2 µg/kg to 69 µg/kg.
- Total dioxin TEQs was detected in all 7 samples with total dioxin TEQs ranging from 0.000001µ/kg to 0.009 µg/kg.
- Copper was detected in 36 of the 41 samples at concentrations ranging from 0.6 mg/kg to 19 mg/kg.
- Lead was detected in all 41 samples at concentrations ranging from 2 mg/kg to 47 mg/kg.
- Mercury was detected in 27 of the 41 samples at concentrations ranging from 0.003 mg/kg to 0.1 mg/kg.
- Zinc was detected in 39 of the 41 samples at concentrations ranging from 7 mg/kg to 310 mg/kg.

Mississippi River Water

A summary of the surface water analytical data is presented in Table 5-15 and Figures 5-14a through 5-14ad.

- VOCs were detected in 31 of the 43 samples with total VOC concentrations ranging from 0.3 µg/l to 74 µg/l.

- SVOCs were detected in 20 of 43 samples with the total SVOC concentrations ranging from 1 µg/l to 380 µg/l.
- Pesticides were detected in 9 of 42 valid samples with total pesticide concentrations ranging from 0.008 µg/l to 0.02 µg/l. Results of one (R5BU1W) of the 42 samples collected were determined to be invalid during the data validation process and therefore the results are not summarized.
- Herbicides were detected in 25 of the 43 samples with total herbicide concentrations ranging from 0.3 µg/l to 85 µg/l.
- Copper was detected in 2 of the 43 samples at concentrations of 0.04 mg/l and 0.003 mg/l.
- Lead was detected in 5 of the 43 samples at concentrations ranging from 0.003 mg/l to 0.005 mg/l.
- Mercury was detected in 6 of the 43 samples at concentrations ranging from 0.00008 mg/l to 0.0002 mg/l.
- Zinc was detected in 14 of the 43 samples at concentrations ranging from 0.004 mg/l to 0.04 mg/l.

No constituent concentrations were detected above the corresponding laboratory detection limit for PCBs and total dioxin TEQs.

5.10.2 Site Q Pond Sampling

One surface water and sediment sample was collected from the large pond located in Site Q during 2002. The analytical results for the pond samples were collected during 2003 will be reported in the addendum to the BERA, which will be submitted after the submittal of this RI/FS report. The surface water and sediment samples were analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, and metals, and three of the samples were also analyzed for dioxins. The detected concentration ranges for each constituent suite are provided below.

Pond Sediment

A summary of pond sediment analytical data is presented in Table 5-14 and Figures 5-13a through 5-13ad.

- VOCs were detected in the sample with a total VOC concentration of 2,927 µg/kg.
- PCBs were detected in the sample with a total PCB concentration of 1,159 µg/kg.
- Total dioxin TEQs were detected in the sample with a value of 0.09 µg/kg.
- Copper was detected in the sample at a concentration of 30 mg/kg.
- Lead was detected in the sample at a concentration of 43 mg/kg.
- Mercury was detected in the sample at a concentration of 0.13 mg/kg.
- Zinc was detected in the sample at a concentration of 190 mg/kg.

No constituent concentrations were detected above the corresponding laboratory detection limit for SVOCs, pesticides, and herbicides.

Pond Water

A summary of the pond surface water analytical data is presented in Table 5-15 and Figures 5-14a through 5-14ad.

- Pesticides were detected in the sample with a total pesticide concentration of 0.04 µg/l.
- Total dioxin TEQs were detected in the sample with a value of 0.000005 µg/l.
- Copper was detected in the sample at a concentration of 0.013 mg/l.
- Lead was detected in the sample at a concentration of 0.014 mg/l.
- Zinc was detected in the sample at a concentration of 0.052 mg/l.

No constituent concentrations were detected above the corresponding laboratory detection limit for VOCs, SVOCs, herbicides, PCBs or mercury.

5.11 QUALITY ASSURANCE

5.11.1 Field Audits

An internal field audit of URS field sampling activities and procedures was performed on August 2, 7, and 14, 2002. The purpose of this audit was to ensure that field efforts were being performed in a manner consistent with the procedures outlined in the Sampling Plan and consistent with procedures developed for sound environmental practices. The audit results indicate that overall field procedures were being conducted in accordance with the Sampling

Plan and established sound environmental practices. The field audit checklist sheet is presented in Appendix F.

SECTIONSIX Source, Nature and Extent of Contamination

The SA2 Sites were formerly used for the disposal of industrial, commercial, and municipal liquid and solid waste. As previously discussed, soil, waste and groundwater samples in addition to other media, were collected from these disposal areas to determine the nature and extent of the fill areas and the nature and extent of the soil and groundwater impact associated with these fill areas. These samples were analyzed for VOCs, SVOCs, pesticides, herbicides, PCBs, dioxins, and metals. Based on a review of this data as discussed in Section 5 and presented in Tables 5-1a through 5-15 and Figures 5-1a through 5-14ad, VOC and SVOC concentrations were determined to be the most representative indicator of the nature and extent of contamination at these sites since they were the most frequently detected constituents above laboratory detection limits at all five disposal sites, therefore, they are considered to be wide-spread throughout the study area. As a result, the observed nature and extent of the soil and groundwater impact observed at each disposal site, using total VOC and total SVOC concentrations for each sample as indicator constituents, is discussed in the following sections. Figure 6-1 provides the locations of geologic cross-sections, presented in Figures 6-2 through 6-6, which are discussed in the following section.

6.1 SITE O

Site O was formerly used as part of the Village of Sauget Waste Water Treatment Plant and consisted of four lagoons, that were used to dispose of clarifier sludge from the treatment plant. The lagoons operated from 1966/67 through 1978. Following the cessation of operations, the lagoons were closed by stabilizing the sludge with lime and covering them with approximately 2 feet of clean low-permeability soil.

A combination of soil, waste, and groundwater samples were collected at Site O during the investigation activities. Figure 3-2 presents the sample locations and a geologic cross-section is presented on Figure 6-3, which summarizes the results of sample analyses which are discussed below.

Soil

The surface material at Site O consists of a silty clay cap, which averages approximately 3.5 feet thick. All six surface and subsurface soil samples (three from each matrix) contained constituent concentrations above the corresponding laboratory detection limits. The subsurface soil sample

concentrations were generally two to three orders of magnitude higher than concentrations in the surface samples.

Waste Material and Volume

Underlying the silty clay cap, the waste material consists of black sludge and averages approximately 12-feet thick. Based on this average thickness of waste material and the surface area of Site O, the estimated waste volume has been calculated as 685,961 cubic yards (Table 6-1).

All three waste samples collected in Site O contained constituent concentrations above the corresponding laboratory detection limits, and these concentrations were typically higher than those observed in the subsurface soil samples. In addition, TCLP extract concentrations exceeded the laboratory detection limit in all 3 samples, however, the TCLP extract results were typically several orders of magnitude lower than the total concentrations. These lower TCLP extract concentrations and the relative age of the waste suggests that the waste material is not a significant source of impact to the underlying alluvial aquifer (Table 6-2a).

A comparison of the standard TCLP results for waste samples to the RCRA toxicity characteristic regulatory levels indicates that this material could be classified as a characteristically hazardous waste (Table 6-3).

NAPL

During the field activities, each soil, waste and groundwater sample was visually inspected for the presence of NAPL in accordance with the procedures described in the FSP. No NAPL was observed at Site O.

Leachate

One leachate well was installed at Site O, and sufficient leachate was present to collect a sample during the first quarterly sampling effort. The leachate well did not contain enough liquid to be sampled during the last three quarterly groundwater sampling events. The results of the leachate well sampling indicate that constituents may be transferred from the waste material to the underlying alluvial aquifer.

Groundwater

Groundwater samples were collected from both the alluvial aquifer and the bedrock aquifer at Site O. Both upgradient and downgradient alluvial groundwater samples were collected to vertically profile the alluvial aquifer at Site O. All of the alluvial and bedrock aquifer groundwater sample locations contained constituent concentrations above the laboratory reporting limit.

All of the alluvial aquifer samples showed significantly lower concentrations than the corresponding waste samples (4-6 orders of magnitude), and the constituent concentrations generally increased with depth below the ground surface, resulting in the highest concentrations in the DHU.

The highest constituent concentrations in the alluvial aquifer were observed upgradient of Site O and generally decreased across the site and with distance from the site as seen in the samples from the borings located further downgradient (AA-O-2 and AA-O-3, respectively). The relationships between the observed impacts in the various media and horizons are provided below. Constituent concentrations in the alluvial aquifer were one to two orders of magnitude higher than those in the bedrock aquifer samples. At Site O, the total concentrations of VOCs and SVOCs in the bedrock samples were less than 1 ppb.

Sediment and Surface Water

The Mississippi River sediment and surface water samples that were collected downgradient of Site O (adjacent to Site R) contained constituent concentrations above the laboratory detection limit. However, Sites R and Q North are between the downgradient edge of Site O and the Mississippi River, therefore, these constituent concentrations may not be attributable to Site O.

Summary

Constituent concentrations generally increased from the soil to the waste and subsequently decreased from the waste to the groundwater as illustrated in the summary table below, which shows maximum total VOC and SVOC concentrations in the respective media.

SITE O

Matrix		Total VOCs (ppb)	Total SVOCs (ppb)
Surface Soil		92,130	2,341
Waste and/or Subsurface Soil		18,484,000	2,884,000
Leachate	Leachate	5,131	11,766
	TCLP Extract	11,383	8,820
Groundwater	Shallow	35	12
	Medium	188	10
	Deep	1,500	122
	Bedrock	1	ND
Sediment		11,061	3,298
Surface Water		74	380

The relative age of the waste (disposal from 1966/67 to 1978), leachate and TCLP-extract concentrations being one to four orders of magnitude lower than waste concentrations, and the shallow groundwater concentrations being two to three orders of magnitude lower than leachate and TCLP-extract concentrations suggest that the wastes present in Site O are not currently a significant on-going source of impact to the underlying aquifer (Table 6-2a).

Evidence of a source upgradient of Site O becomes apparent when upgradient groundwater concentrations are compared to downgradient concentrations.

Matrix	Distance From Site Boundary (ft)	Total VOCs (ppb)	Total SVOCs (ppb)
UAA-2	350 (upgradient)	2,739	1,337
AA-O-1	100 (downgradient)	1,500	122
AA-O-2	250 (downgradient)	1,008	71
AA-O-3	730 (downgradient)	692	31

Total VOC concentrations 350 feet upgradient of Site O are 2,739 ppb while total VOC concentrations are 1,500 ppb 100 feet downgradient of the site. A similar pattern is observed for total SVOCs with upgradient concentrations of 1,337 ppb and downgradient concentrations of 122 ppb. Further evidence for an upgradient source is the observation that total VOC and total SVOC concentrations at Site O increase with depth. Since groundwater concentrations are higher upgradient of Site O than downgradient and the concentrations increase with depth, there is evidence of an upgradient source.

While sediments and surface water downgradient of Site O contain total VOC concentrations of 11,061 and 74 ppb, respectively, and total SVOC concentrations of 3,298 and 380 ppb, respectively, it is unlikely that Site O is the source of these observed concentrations. Maximum observed total VOC and total SVOC concentrations in groundwater at Site O are 1,500 ppb and 122 ppb, respectively. Both total VOC and total SVOC concentrations in groundwater are lower than concentrations observed in sediments and surface water downgradient of Site O by one to two orders of magnitude. Maximum observed concentrations of total VOCs (106,250 ppb) and total SVOCs (123,147 ppb) in groundwater at Site R indicates that Site R is a more likely primary source for the observed sediment and surface water concentrations than Site O.

6.2 SITE P

Site P was formerly operated as an IEPA-permitted landfill from 1973 to approximately 1984. The landfill accepted general wastes from Edwin Cooper and Monsanto. Site P is currently inactive and partially covered.

A combination of soil, waste, and groundwater samples were collected at Site P during the investigation activities. Figure 3-2 presents the sample locations and a geologic cross-section is presented on Figure 6-3, which summarizes the results of sample analyses which are discussed below.

Soil

The surface material at Site P consists of silty clay and black cinders, which average approximately 0.5-feet thick. All eight surface and subsurface soil samples (four from each matrix) contained constituent concentrations above the corresponding laboratory detection limits. The subsurface soil sample concentrations were generally one to three orders of magnitude higher than concentrations in the surface samples.

Waste Material and Volume

Underlying the silty clay, the waste material consists of municipal waste and construction debris that averages approximately 23-feet thick. Based on this average thickness of waste material and the surface area of Site P, the estimated waste volume has been calculated as 634,588 cubic yards (Table 6-1).

All four waste samples contained constituent concentrations above the corresponding laboratory detection limits and these concentrations were typically higher than those observed in the subsurface soil samples. In addition, TCLP extract concentrations exceeded the laboratory detection limit in all 4 samples, however, the TCLP extract results were typically several orders of magnitude lower than the total concentrations. These lower TCLP extract concentrations and the relative age of the waste suggests that the waste material is not a significant source of impact to the underlying alluvial aquifer (Table 6-2b). In addition, the standard TCLP results did not exceed the RCRA toxicity characteristic regulatory levels.

NAPL

During the field activities, each soil, waste and groundwater sample was visually inspected for the presence of NAPL in accordance with the procedures described in the FSP. No NAPL was observed in Site P.

Leachate

One leachate well was installed at Site P, which did not contain enough liquid to be sampled during any of the four quarterly groundwater sampling events.

Groundwater

Groundwater samples were collected from both the alluvial aquifer and the bedrock aquifer at Site P. Both upgradient and downgradient alluvial groundwater samples were collected to vertically profile the alluvial aquifer at Site P. All of the alluvial and bedrock aquifer groundwater sample locations contained constituent concentrations above the laboratory reporting limit.

All of the alluvial aquifer samples showed significantly lower concentrations than the corresponding waste samples (1-4 orders of magnitude), and the constituent concentrations generally increased with depth below the ground surface resulting in the highest concentrations

in the DHU. Constituent concentrations in the alluvial aquifer were one to two orders of magnitude higher than those in the bedrock aquifer samples. At Site P, the total concentrations of VOCs and SVOCs in the bedrock samples were 82 and 15 ppb, respectively.

The highest constituent concentrations in the alluvial aquifer were observed downgradient of Site P in AA-P-2. Generally, constituent concentrations increased immediately downgradient of the site, before decreasing significantly in AA-P-3 (located furthest downgradient).

Sediment/Surface Water

The constituent concentrations observed in the sediment associated with the Mississippi River downgradient of Site P were two orders of magnitude lower than the most impacted downgradient portion of the alluvial aquifer. The total concentrations of VOCs and SVOCs in the surface water samples were less than 1 ppb.

Summary

Constituent concentrations generally increased from the soil to the waste and subsequently decreased from the waste to the groundwater as illustrated in the summary table below, which shows maximum total VOC and SVOC concentrations in the respective media.

Matrix		Total VOCs (ppb)	Total SVOCs (ppb)
Surface Soil		85	9,507
Waste and/or Subsurface Soil		464,920	179,380
Leachate	Leachate	N/A	N/A
	TCLP	1,259	3,543
Groundwater	Shallow	47	ND
	Medium	6	26
	Deep	7,632	285
	Bedrock	82	15
Sediment		48	178
Surface Water		0.7	ND

The relative age of the waste (disposal from 1973 to 1984), the TCLP-extract concentrations being one to four orders of magnitude lower than waste concentrations, and the shallow groundwater concentrations being two to three orders of magnitude lower than the TCLP-extract concentrations suggest that the wastes present in Site P are not currently a significant on-going source of impact to the underlying aquifer (Table 6-2b).

Two lines of evidence point to an upgradient contribution of constituents, if not an upgradient source, of the observed downgradient constituent concentrations at Site P. The first line of evidence compares the upgradient concentrations to the downgradient concentrations. As shown in the table below, the constituent concentrations increase by one order of magnitude from 714 and 49 ppb upgradient to 5,090 and 169 ppb downgradient for total VOCs and SVOCs, respectively. However, the presence of VOCs and SVOCs at these concentrations upgradient, indicates that some constituents are moving onto Site P.

SITE P

Matrix	Distance From Site Boundary (ft)	Total VOCs (ppb)	Total SVOCs (ppb)
UAA-1	100 (upgradient)	714	49
AA-P-1	280 (downgradient)	5,090	169
AA-P-2	790 (downgradient)	7,632	285
AA-P-3	1,900 (downgradient)	17	0

Secondly, a comparison of the vertical distribution of concentrations throughout the borings shows concentrations two to three orders of magnitude higher in the DHU than in the SHU or MHU. The presence of upgradient constituent concentrations and the observed vertical concentration gradient indicate the migration of constituents from an upgradient source.

The sediments and surface water downgradient of Site P contain total VOC concentrations of 48 and 0.6 ppb, respectively, and total SVOC concentrations of 178 and 0 ppb, respectively. In addition, both total VOC and total SVOC concentrations in groundwater in the most downgradient sampling location are lower than concentrations observed in sediments and

downgradient of Site P. These concentrations are two to four order of magnitude lower than the highest groundwater concentrations.

The sediments and surface water downgradient of Site P contain total VOC concentrations of 48 and 0.7 ppb, respectively, and total SVOC concentrations of 178 and 0 ppb, respectively. In addition, both total VOC and total SVOC concentrations in groundwater in the most downgradient sampling location are lower than concentrations observed in sediments and downgradient of Site P. These concentrations are two to four order of magnitude lower than the highest groundwater concentrations.

6.3 SITE Q

Site Q was formerly a subsurface and surface disposal area, which consisted of municipal wastes, septic tank pumpings, organic and inorganic wastes, solvents, pesticides, paint sludge, plant trash, and demolition debris.

6.3.1 Site Q North

A combination of soil, waste, and groundwater samples were collected at Site Q North during the investigation activities. Figure 3-2 presents the sample locations and a geologic cross-section is presented on Figure 6-3, which summarizes the results of sample analyses which are discussed below.

Soil

The surface material at Site Q North generally consists gravel and of black cinders. All ten surface and subsurface soil samples (five from each matrix) contained constituent concentrations above the corresponding laboratory detection limits. The subsurface soil sample concentrations were generally one to three orders of magnitude higher than those in the surface samples.

Waste Material and Volume

The waste material consists of black cinders, industrial waste, municipal wastes and construction debris and averages approximately 12-feet thick. Based on this average thickness of waste material and the surface area of Site Q North, the estimated waste volume has been calculated as 1,076,957 cubic yards (Table 6-1).

All five waste samples collected in Site Q North contained constituent concentrations above the corresponding laboratory detection limits and these waste concentrations were typically higher

than those observed in the subsurface soil samples. In addition, TCLP extract concentrations exceeded the laboratory detection limit in all 4 samples, however, the TCLP extract results were typically several orders of magnitude lower than the total concentrations. These lower TCLP extract concentrations and the relative age of the waste suggests that the waste material is not a significant source of impact to the underlying alluvial aquifer (Table 6-2c).

A comparison of the standard TCLP results for waste samples to the RCRA toxicity characteristic regulatory levels indicates that characteristically hazardous waste is present at Site Q North (Table 6-3).

NAPL

During the field activities, each soil, waste and groundwater sample was visually inspected for the presence of NAPL in accordance with the procedures described in the FSP. NAPL was observed in the waste sample collected at Waste-Q-1 and during trenching activities at Boundary Trench-Q-1. DNAPL was observed in the leachate well, Leach-Q-1 during each of the four quarterly sampling events. In accordance with the FSP, the presence of NAPL at these three sampling/investigation locations was documented.

Leachate

One leachate well was installed at Site Q North and sufficient leachate was present to collect a sample during each of the four quarterly sampling efforts. The results of the leachate well sampling indicate that constituents may be transferred from the waste material to the underlying alluvial aquifer.

Groundwater

Groundwater samples were collected from both the alluvial aquifer and the bedrock aquifer at Site Q North. All of the alluvial and bedrock aquifer groundwater sample locations contained constituent concentrations above the laboratory reporting limit.

All of the alluvial aquifer samples showed significantly lower concentrations from the corresponding waste samples (two to four orders of magnitude), and the constituent concentrations generally increased with depth below the ground surface. Constituent concentrations in the alluvial aquifer were two orders of magnitude higher than the bedrock aquifer samples. At Site Q North, the total concentrations of VOCs and SVOCs in the bedrock sample was 4 and 5 ppb, respectively.

The constituent concentrations in the alluvial aquifer were observed to increase by an order of magnitude in Site Q North compared to immediately upgradient of Site Q.

Sediment/Surface Water

The sediment and surface water samples that were collected downgradient of Site Q North (adjacent to Site R) contained constituent concentrations above the laboratory detection limit. However, Site R is between the downgradient edge of Site Q North and the Mississippi River. Therefore, these constituent concentrations may not be attributable to Site Q North.

Summary

Constituent concentrations generally increased from the soil to the waste and subsequently decreased from the waste to the groundwater as illustrated in the summary table below, which shows maximum total VOC and SVOC concentrations in the respective media.

SITE Q NORTH

Matrix		Total VOCs (ppb)	Total SVOCs (ppb)
Surface Soil		25	21,782
Waste and/or Subsurface Soil		374,550	388,830
Leachate	Leachate	9,579	270,540
	TCLP	2,516	32,792
Groundwater	Shallow	NA	NA
	Medium	254	178
	Deep	918	2,959
	Bedrock	4	5
Sediment		11,061	3,298
Surface Water		74	380

The relative age of the waste (disposal from the 1950s to the 1970s), the leachate and TCLP-extract concentrations being one to four orders of magnitude lower than waste concentrations, and the shallow groundwater concentrations being two to three orders of magnitude lower than

the leachate and TCLP-extract concentrations suggest that the wastes present in Site Q North are not currently a significant on-going source of impact to the underlying aquifer (Table 6-2c).

Two lines of evidence point to an upgradient contribution of constituents, if not an upgradient source, of the observed downgradient constituent concentrations at Site Q North. The first line of evidence begins with the concentrations observed upgradient of Sites O and S and migrating downgradient towards Site Q North. A comparison of these concentrations to the downgradient concentrations, as shown in the table below, shows a constituent concentrations increase by one order of magnitude from 531 and 19 ppb upgradeint to 918 and 2,959 ppb downgradient for total VOCs and SVOCs respectively. However the presence of VOCs and SVOCs at these concentrations upgradient, indicates that some constituents are moving onto Site Q North.

SITE Q NORTH

Sample	Distance From Site Boundary (ft)	Total VOCs (ppb)	Total SVOCs (ppb)
AA-S-3	100 (upgradient)	531	19
AA-Q-1	--	918	2,959

Secondly, a comparison of the vertical distribution of concentrations throughout the borings shows concentrations higher in the DHU than in the SHU or MHU. While this observed vertical concentration gradient could be due to the presence of DNAPL blobs or ganglia in the aquifer matrix beneath Site Q North, it could also be due, in whole or in part, to migration from an upgradient source.

While sediments and surface water downgradient of Site Q North contain total VOC concentrations of 11,061 and 74 ppb, respectively, and total SVOC concentrations of 3,298 and 380 ppb, respectively, it is unlikely that Site Q North is the source of these observed concentrations. Maximum observed total VOC and total SVOC concentrations in groundwater at Site Q North are 918 ppb and 2,959 ppb, respectively. The concentrations of both VOCs and SVOCs in the groundwater are at or below the concentrations observed in the sediment downgradient of Site Q North. Maximum observed concentrations of total VOCs (106,250 ppb)

and total SVOCs (123,147 ppb) in groundwater at Site R indicates that Site R is a more likely the primary source for the observed sediment and surface water concentrations than Site Q North.

6.3.2 Site Q Central

A combination of soil, waste, and groundwater samples were collected at Site Q Central during the investigation activities. Figure 3-2 presents the sample locations and a geologic cross-section is presented on Figure 6-5, which summarizes the results of sample analyses which are discussed below.

Soil

The surface material at Site Q Central generally consists of gravel, mulch, and black cinders. All six surface and subsurface soil samples (three from each matrix) contained constituent concentrations above the corresponding laboratory detection limits. The subsurface soil sample concentrations were generally an order of magnitude higher than those in the surface samples.

Waste Material and Volume

The waste material consists of black cinders with municipal waste and construction debris and averages approximately 17-feet thick. Based on this average thickness of waste material and the surface area of Site Q Central, the estimated waste volume has been calculated as 1,812,342 cubic yards (Table 6-1).

All three waste samples collected in Site Q Central contained constituent concentrations above the corresponding laboratory detection limits and these concentrations were generally higher than those observed in the subsurface soil samples. In addition, TCLP extract concentrations exceeded the laboratory detection limit in all 4 samples, however, the TCLP extract results were typically several orders of magnitude lower than the total concentrations. These lower TCLP extract concentrations and the relative age of the waste suggests that the waste material is not a significant source of impact to the underlying alluvial aquifer (Table 6-2c). In addition, the standard TCLP results did not exceed the RCRA toxicity characteristic regulatory levels.

NAPL

During the field activities, each soil, waste and groundwater sample was visually inspected for the presence of NAPL in accordance with the procedures described in the FSP. No NAPL was observed in Site Q Central.

Leachate

One leachate well was installed at Site Q Central, which did not contain enough liquid to be sampled during any of the four quarterly groundwater sampling events.

Groundwater

Groundwater samples were collected from both the alluvial aquifer and the bedrock aquifer at Site Q Central. All of the alluvial and bedrock aquifer groundwater samples contained constituent concentrations above the laboratory reporting limit.

All of the alluvial aquifer samples showed significantly lower concentrations from the corresponding waste samples (2-3 orders of magnitude). The highest constituent concentrations in the alluvial aquifer were observed in the southern portion of Site Q Central at AA-Q-5. Constituent concentrations in the alluvial aquifer were one to two orders of magnitude higher than the bedrock aquifer samples. At Site Q Central, the total concentrations of VOCs and SVOCs in the bedrock sample was 4 and 5 ppb, respectively.

Sediment/Surface Water

The constituent concentrations observed in the sediment and surface water associated with the Mississippi River downgradient of Site Q Central were generally two orders of magnitude lower than the most impacted downgradient portion of the alluvial aquifer. The total concentrations of VOCs in the sediment samples were not above 15 ppb, while the total concentrations for SVOCs was 66 ppb. The total concentrations of VOCs and SVOCs in the surface water samples were 45 and 18 ppb, respectively.

Summary

Constituent concentrations generally increased from the soil to the waste and subsequently decreased from the waste to the groundwater as illustrated in the summary table below, which shows maximum total VOC and SVOC concentrations in the respective media.

SITE Q CENTRAL

Matrix		Total VOCs (ppb)	Total SVOCs (ppb)
Surface Soil		341	7,120
Waste and/or Subsurface Soil		40,788	77,227
Leachate	Leachate	N/A	N/A
	TCLP	400	141
Groundwater	Shallow	NA	NA
	Medium	483	519
	Deep	99	389
	Bedrock	4	5
Sediment		15	66
Surface Water		45	18

The relative age of the waste (disposal from the 1950s to the 1970s), the TCLP-extract concentrations being one to four orders of magnitude lower than waste concentrations, and the shallow groundwater concentrations being two to three orders of magnitude lower than the TCLP-extract concentrations suggest that the wastes present in Site Q Central are not currently a significant on-going source of impact to the underlying aquifer (Table 6-2c).

Sediments and surface water downgradient of Site Q Central contain total VOC concentrations of 15 and 45 ppb, respectively, and total SVOC concentrations of 66 and 18 ppb, respectively. Maximum observed total VOC and total SVOC concentrations in groundwater at Site Q Central are 483 ppb and 519 ppb, respectively. Both total VOC and total SVOC concentrations in sediment and surface water are extremely low and are one to two orders of magnitude lower than the maximum groundwater concentrations.

6.3.3 Site Q South

A combination of soil, waste, and groundwater samples were collected at Site Q South during the investigation activities. Figure 3-2 presents the sample locations and a geologic cross-section is presented on Figure 6-6, which summarizes the results of sample analyses which are discussed below.

Soil

The surface material at Site Q South generally consists of both silty clay and gravel, mulch, and black cinders. All eight surface and subsurface soil samples (four from each matrix) contained constituent concentrations above the corresponding laboratory detection limits. The subsurface soil sample concentrations were generally one order of magnitude higher than those in the surface samples.

Waste Material and Volume

The waste material consists of black cinders with municipal waste and construction debris and averages approximately 10-feet thick. Based on this average thickness of waste material and the surface area of Site Q South, the estimated waste volume has been calculated as 1,115,003 cubic yards (Table 6-1).

All four waste samples collected in Site Q South contained constituent concentrations above the corresponding laboratory detection limits and these concentrations were typically higher than those observed in the subsurface soil samples for total VOCs. In addition, TCLP extract concentrations exceeded the laboratory detection limit in all 4 samples, however, the TCLP extract results were typically several orders of magnitude lower than the total concentrations. These lower TCLP extract concentrations and the relative age of the waste suggests that the waste material is not a significant source of impact to the underlying alluvial aquifer (Table 6-2c). In addition, the standard TCLP results did not exceed the RCRA toxicity characteristic regulatory levels.

NAPL

During the field activities, each soil, waste and groundwater sample was visually inspected for the presence of NAPL in accordance with the procedures described in the FSP. No NAPL was observed at Site Q South.

Leachate

One leachate well was installed at Site Q South, which did not contain enough liquid to be sampled during any of the four quarterly groundwater sampling events.

Groundwater

Groundwater samples were collected from both the alluvial aquifer and the bedrock aquifer at Site Q South. Both upgradient and downgradient alluvial groundwater samples were collected to vertically profile the alluvial aquifer at Site Q South.

All of the alluvial aquifer samples showed generally lower concentrations than the corresponding waste samples. The highest constituent concentrations in the alluvial aquifer were observed in the northern portion of Site Q South in AA-Q-6. Constituent concentrations in the alluvial aquifer were one to three orders of magnitude higher than the bedrock aquifer samples. At Site Q South, the total concentrations of VOCs and SVOCs in the bedrock samples were 7 ppb and non-detect, respectively.

Sediment/Surface Water

The constituent concentrations observed in the sediment associated with the Mississippi River downgradient of Site Q South were generally two orders of magnitude lower than the most impacted portion of the alluvial aquifer. The total concentrations of VOCs and SVOCs in the surface water samples were less than 3 ppb.

Summary

Constituent concentrations generally increased from the soil to the waste and subsequently decreased from the waste to the groundwater as illustrated in the summary table below, which shows maximum total VOC and SVOC concentrations in the respective media.

SITE Q SOUTH

Matrix		Total VOCs (ppb)	Total SVOCs (ppb)
Surface Soil		130	24,126
Waste and/or Subsurface Soil		3,484,460	51,120
Leachate	Leachate	N/A	N/A
	TCLP	234	273
Groundwater	Shallow	12,052	593
	Medium	1,115	62
	Deep	611	47
	Bedrock	7	ND
Sediment		294	390
Surface Water		3	3

The relative age of the waste (disposal from 1996/67 to 1978), the TCLP-extract concentrations being one to four orders of magnitude lower than waste concentrations, and the shallow groundwater concentrations being two to three orders of magnitude lower than the TCLP-extract concentrations suggest that the wastes present in Site Q South are not currently a significant on-going source of impact to the underlying aquifer (Table 6-2c).

The sediment and surface water downgradient of Site Q South contain total VOC concentrations of 294 and 3 ppb, respectively, and total SVOC concentrations of 390 and 3 ppb, respectively. These concentrations are two to four orders of magnitude lower than the highest groundwater concentration.

6.4 SITE R

Site R was formerly an industrial-waste disposal area and consisted of hazardous and non-hazardous bulk liquid and solid chemical and drummed chemical wastes. The site currently has a silty clay cap with a vegetative cover.

A combination of soil, waste, and groundwater samples were collected at Site R during the investigation activities. Figure 3-2 presents the sample locations and a geologic cross-section is presented on Figure 6-3, which summarizes the results of sample analyses which are discussed below.

Soil

The surface material at Site R consists of a silty clay cap, which averages approximately 7 feet thick. All eight surface and subsurface soil samples (four from each matrix) contained constituent concentrations above the corresponding laboratory detection limits. The subsurface soil sample concentrations were generally one to four orders of magnitude higher than those in the surface samples.

Waste Material and Volume

Underlying the silty clay cap was waste material consisting of impacted black cinders and averages approximately 25-feet thick. Based on this average thickness of waste material and the surface area of Site R, the estimated waste volume has been calculated as 883,254 cubic yards (Table 6-1).

All four waste samples collected in Site R contained constituent concentrations above the corresponding laboratory detection limits and these concentrations were typically higher than those observed in the subsurface soil samples. In addition, TCLP extract concentrations exceeded the laboratory detection limit in all 4 samples, however, the TCLP extract results were typically several orders of magnitude lower than the total concentrations (Table 6-2d).

A comparison of the standard TCLP results for waste samples to the RCRA toxicity characteristic regulatory levels indicates that material classified as a characteristically hazardous waste is present at Site R (Table 6-3).

NAPL

During the field activities, each soil, waste and groundwater sample was visually inspected for the presence of NAPL in accordance with the procedures described in the FSP. NAPL was observed in the waste sample collected at Waste-R-3. In addition, DNAPL was observed in the leachate well Leach-R-1. In accordance with the FSP, the presence of NAPL at these three

sampling/investigation locations was documented, however, no attempt was made to further investigate the nature or extent of this NAPL material.

Leachate

As part of the pre-design investigation for the SA2IGR, five borings were completed with rotosonic drilling technology in May 2002 to provide geological and geotechnical information along the proposed alignment of the barrier wall. Boring Sonic No. 5 was completed to bedrock on May 3, 2002 on Eagle Marine property just beyond the southeastern corner of Site R. DNAPL was observed in a soil sample from 138 to 141 feet bgs and an "oil" sample was collected from this soil sample by gravity drainage. This sample was sent to STL in Savannah, Georgia and the following constituents were detected:

- Chlorobenzene 1,600,000 ppb
- 1,2-Dichlorobenzene 21,000,000 ppb
- 1,2,4-Trichlorobenzene 4,500,000 ppb
- Trichlorobiphenyl 17,000 ppb
- Tetrachlorobiphenyl 25,000 ppb

One leachate well was installed at Site R, and sufficient leachate was present to collect a sample during each of the four quarterly sampling efforts. The results of the leachate well sampling indicate that constituents may be transferred from the waste material to the underlying alluvial aquifer.

Groundwater

Groundwater samples were collected from both the alluvial aquifer and the bedrock aquifer at Site R. All of the alluvial and bedrock aquifer groundwater sample locations contained constituent concentrations above the laboratory reporting limit.

All of the alluvial aquifer samples showed significantly lower concentrations than the corresponding waste samples (1-5 orders of magnitude), and the highest constituent concentrations were observed in the MHU.

The highest constituent concentrations in the alluvial aquifer were observed downgradient of Site R.

Constituent concentrations in the alluvial aquifer were three to four orders of magnitude higher than the bedrock aquifer samples. At Site R, the total concentrations of VOCs and SVOCs in the bedrock samples were 89 and 1,622 ppb, respectively.

Sediment/Surface Water

The constituent concentrations observed in the sediment and surface water associated with the Mississippi River downgradient of Site R may be attributable to the site. The sediment and surface water samples are generally two to four orders of magnitude lower than the most impacted portion of the alluvial aquifer.

Summary

Constituent concentrations generally increased from the soil to the waste and subsequently decreased from the waste to the groundwater as illustrated in the summary table below, which shows maximum total VOC and SVOC concentrations in the respective media.

SITE R

Matrix		Total VOCs (ppb)	Total SVOCs (ppb)
Surface Soil		200	331
Waste and/or Subsurface Soil		4,532,200	5,807,000
Leachate	Leachate	206,734,000	9,713,800
	TCLP Extract	208,420	160,346
Groundwater	Shallow	2,582	11,360
	Medium	106,250	123,147
	Deep	18,825	25,540
	Bedrock	89	1,622
Sediment		11,061	3,298
Surface Water		74	379

While there are sources at Site Q North and upgradient of Site O, a comparison of the upgradient and downgradient concentrations show that Site R contributes the vast majority of the observed concentrations.

SITE R

Matrix	Distance From Site Boundary (ft)	Total VOCs (ppb)	Total SVOCs (ppb)
AA-O-3	460 (upgradient)	692	31
AA-R-1	100 (downgradient)	106,250	123,147

The sediments and surface water downgradient of Site R contain total VOC concentrations of 11,061 and 74 ppb, respectively, and total SVOC concentrations of 3,298 and 379 ppb, respectively. Maximum observed concentrations of total VOCs (106,250 ppb) and total SVOCs (123,147 ppb) in groundwater at Site R indicates that Site R is likely the primary source for the observed sediment and surface water concentrations downgradient of Site R.

6.5 SITE S

Site S was formerly a subsurface disposal area and consists of industrial waste. Site S is currently covered with a silty clay cap and vegetative cover in the northern half and a gravel cover in the southern half.

A combination of soil, waste, and groundwater samples were collected at Site S during the investigation activities. Figure 3-2 presents the sample locations and a geologic cross-section is presented on Figure 6-4, which summarizes the results of sample analyses which are discussed below.

Soil

The surface material at Site S consists of a silty clay cap, which averages approximately 0.5-feet thick and is covered by gravel and vegetation. All four surface and subsurface soil samples (two from each matrix) contained constituent concentrations above the corresponding laboratory

detection limits. The subsurface soil sample concentrations were generally one to five orders of magnitude higher than those in the surface samples.

Waste Material and Volume

Underlying the silty clay cap, the waste material consists of sand impacted by industrial waste material and averages approximately 8.5-feet thick. Based on this average thickness of waste material and the surface area of Site S, the estimated waste volume has been calculated as 11,234 cubic yards (Table 6-1).

The two waste samples collected in Site S contained constituent concentrations above the corresponding laboratory detection limits and these concentrations were typically higher than the subsurface soil samples. In addition, TCLP extract concentrations exceeded the laboratory detection limit in all 4 samples, however, the TCLP extract results were typically several orders of magnitude lower than the total concentrations. These lower TCLP extract concentrations and the relative age of the waste suggests that the waste material is not a significant source of impact to the underlying alluvial aquifer (Table 6-2e).

A comparison of the standard TCLP results for waste samples to the RCRA toxicity characteristic regulatory levels indicates that material that may be classified as a characteristically hazardous waste is present at Site S (Table 6-3).

NAPL

During the field activities, each soil, waste and groundwater sample was visually inspected for the presence of NAPL in accordance with the procedures described in the FSP. NAPL was observed during trenching activities at Boundary Trench-S-2. In accordance with the FSP, the presence of NAPL at this sampling/investigation location was documented.

Leachate

One leachate well was installed at Site S, which did not contain enough liquid to be sampled during any of the four quarterly groundwater sampling events.

Groundwater

Groundwater samples were collected from both the alluvial aquifer and the bedrock aquifer at Site S. Both upgradient and downgradient alluvial groundwater samples were collected to vertically profile the alluvial aquifer at Site S. All of the alluvial and bedrock aquifer

groundwater sample locations contained constituent concentrations above the laboratory reporting limit.

All of the alluvial aquifer samples showed a significant decrease in concentrations from the waste (5 to 6 orders of magnitude), however, the constituent concentration generally increased with depth below ground surface.

The highest constituent concentrations in the alluvial aquifer were observed upgradient of Site S and generally remained constant downgradient from the site.

Constituent concentrations in the alluvial aquifer were one to two orders of magnitude higher than the bedrock aquifer samples. At Site S, the total concentrations of VOCs and SVOCs in the bedrock samples were 5 and 11 ppb, respectively.

Sediment and Surface Water

The sediment and surface water samples that were collected downgradient of Site S (adjacent to Site R) contained constituent concentrations above the laboratory detection limit. However, Site R is between the downgradient edge of Site S and the Mississippi River. Therefore, these constituent concentrations may not be attributable to Site S.

Summary

Constituent concentrations generally increased from the soil to the waste and subsequently decreased from the waste to the groundwater as illustrated in the summary table below, which shows maximum total VOC and SVOC concentrations in the respective media.

SITE S

Matrix		Total VOCs (ppb)	Total SVOCs (ppb)
Surface Soil		14	392,200
Waste and/or Subsurface Soil		16,210,400	503,900
Leachate	Leachate	N/A	N/A
	TCLP Extract	94,660	6,119
Groundwater	Shallow	12	3
	Medium	9	11
	Deep	531	19
	Bedrock	5	11
Sediment		11,061	3,298
Surface Water		74	379

The relative age of the waste (disposal from the mid-1960s to the late 1970s), the TCLP-extract concentrations being one to four orders of magnitude lower than waste concentrations, and the shallow groundwater concentrations being two to three orders of magnitude lower than the TCLP-extract concentrations suggest that the wastes present in Site S are not currently a significant on-going source of impact to the underlying aquifer (Table 6-2e).

Evidence of a source upgradient of Site S becomes apparent when upgradient groundwater concentrations are compared to downgradient concentrations.

Matrix	Distance From Site Boundary (ft)	Total VOCs (ppb)	Total SVOCs (ppb)
UAA-3	1150 (upgradient)	2,155	4,438
AA-S-1	60 (downgradient)	412	10
AA-S-2	190 (downgradient)	340	15
AA-S-3	320 (downgradient)	531	19

Total VOC concentrations 1,150 feet upgradient of Site S are 2,155 ppb while total VOC concentrations are 412 ppb 60 feet downgradient of the site. A similar pattern is observed for total SVOCs with upgradient concentrations of 4,438 ppb and downgradient concentrations of 10 ppb. Further evidence for an upgradient source is the observation that total VOC and total SVOC concentrations at Site S increase with depth. While this observed vertical concentration gradient could be due to the presence of DNAPL blobs or ganglia in the aquifer matrix beneath Site S, it could also be due, in whole or in part, to migration from an upgradient source. Since groundwater concentrations are higher upgradient of Site S than downgradient, there is evidence of an upgradient source.

While sediments and surface water downgradient of Site S contain total VOC concentrations of 11,061 and 74 ppb, respectively, and total SVOC concentrations of 3,298 and 379 ppb, respectively, it is unlikely that Site S is the source of these observed concentrations. Maximum observed total VOC and total SVOC concentrations in groundwater at Site S are 531 ppb and 19 ppb, respectively. Both total VOC and total SVOC concentrations in groundwater are lower than concentrations observed in sediments and surface water downgradient of Site S by one to two orders of magnitude. Maximum observed concentrations of total VOCs (106,250 ppb) and total SVOCs (123,147 ppb) in groundwater at Site R indicates that Site R is more likely the primary source for the observed sediment and surface water concentrations than Site S.

6.6 MAJOR FINDINGS

The major findings of this evaluation of the nature and extent of source areas and the nature and extent of migration from the source areas are:

Source Areas

- Surface soil concentrations were generally lower than subsoil concentrations
- Subsoil concentrations were generally lower than waste concentrations
- Waste concentrations were generally the highest concentrations detected in the source areas
- TCLP-extract concentrations were generally lower than leachate concentrations

Groundwater

- Leachate and TCLP-extract concentrations were generally higher than shallow groundwater concentrations

- Groundwater concentrations generally increased with depth
- Upgradient groundwater concentrations were generally higher than downgradient concentrations at Sites O and S
- Downgradient groundwater concentrations were generally higher than upgradient concentrations at Sites P, Q North and R
- All of the alluvial and bedrock aquifer groundwater sample locations contained constituents concentrations above the laboratory reporting limit and at least one constituent concentration which exceeded the corresponding IEPA Class I Groundwater Standard.

Sediments and Surface Water

- Sediment and surface water concentrations were generally higher downgradient of Sites O, Q North, R and S than downgradient of Sites P, Q Central and Q South.
- All of the alluvial and bedrock aquifer groundwater sample locations contained constituent concentrations above the laboratory reporting limit and at least one constituent concentration which exceeded the corresponding IEPA Class I groundwater standard.

SECTIONSEVEN Groundwater Fate and Transport

As discussed in the Focused Feasibility Study (FFS) Interim Groundwater Remedy (Solutia, 2002) dated March 31, 2002, for SA2 Sites O, Q, R, and S, groundwater fate and transport is controlled by both the characteristics of the groundwater flow regime and the individual constituent characteristics. The following sections discuss both of these controlling factors, as well as, provide observations about the general trends of the constituent migration based on the groundwater modeling that has been conducted.

7.1 CONSTITUENT CHARACTERISTICS

A wide range of constituents are present in groundwater at the SA2 Site. Constituents mobile in the groundwater system at SA2 Sites include:

VOCs	*SVOCs*	
Acetone	Acenapthylene	Dimethylphenol
Benzene	Aniline	Di-n-butylphthalate
Bromoform	Benzo(a)pyrene	Di-n-octylphthalate
2-Butanone	Benzo(k)fluoranthene	Fluoranthene
Chlorobenzene	Benzoic Acid	Hexachlorocylopentadiene
Chloroethane	Benzyl Alcohol	Methyl Naphthalene
Chloroform	Bis(2-choroethoxy)methane	Methylphenol
Dichloroethane	Bis(2-chloroethyl)ether	Naphthalene
Dichloroethylene	Bis(2-ethylhexyl)phthalate	Nitrobenzene
Ethyl Benzene	Bis(2-chloroisopropyl)ether	Nitrochlorobenzene
Methylene Chloride	Chloroaniline	Nitrodiphenylamine
4-methyl 2-Pentanone	4-chloro-3-methylphenol	Nitophenol
Trichloroethane	Chlorophenol	n-Nitosodiphenylamine
Trichloroethylene	Chrysene	Pentachlorophenol
Tetrachloroethane	Dichlorobenzene	Phenol
Toluene	Dichlorobenzidine	Pyrene
Vinyl Chloride	Dichlorophenol	Trichlorophenol
Xylenes		

Metals		
Arsenic	Chromium	Nickel
Barium	Cobalt	Vanadium
Cadmium	Lead	Zinc

7.2 GROUNDWATER FATE AND TRANSPORT PROCESS

As previously discussed, the alluvial groundwater below the site is broken into three hydrogeologic zones; the SHU, MHU, and the DHU. The SHU typically consists of silt and fine sand, while the MHU typically consists of fine to medium sand, which coarsens with depth, and the DHU typically consists of medium to coarse sand and gravel. During normal river stage conditions, groundwater in all three hydrogeologic zones flows from east to west toward the Mississippi River, which is the natural discharge point for groundwater in the American Bottoms aquifer. However, during flood stage conditions, the groundwater flow in all three hydrogeologic zones reverses and flows from the Mississippi River into the aquifer.

The average hydraulic conductivities determined from slug test results in the SHU, MHU, and DHU were 4.8×10^{-3} cm/sec, 3.9×10^{-2} cm/sec, and 2.4×10^{-2} cm/sec, respectively. In addition, the average hydraulic conductivity observed in the bedrock was 4.1×10^{-3} cm/sec. A summary of the hydraulic conductivities is provided in Tables 5-13a through 5-13d. These hydraulic conductivities resulted in groundwater flow rates of 0.03 ft/day (11 ft/yr), 0.74 ft/day (270 ft/yr), and 1.56 ft/day (569 ft/yr) in the SHU, MHU, and DHU respectively. Processes such as dispersion, dilution, biodegradation, adsorption, precipitation, and groundwater flow direction reversal will retard or slow the movement of site-related constituents migrating toward the Mississippi River in the MHU and DHU. However, it is unlikely that these processes have much of an effect given the high groundwater flow velocities in the MHU and DHU and the short distance from Sites R and Q to the river.

7.3 GROUNDWATER CONSTITUENT MIGRATION TRENDS

Based on the groundwater analytical results discussed in Section 5 and the nature and extent of the source areas discussed in Section 6 and the isoconcentration maps presented in Figures 7-1 through 7-10, it appears as though there are three groundwater plumes located below the SA2 Sites. The first plume appears to be coming onto the site at the eastern boundary along Illinois Route 3 (plume 1), the second plume is adjacent to Site R (plume 2), and the third plume is located in Site Q South (plume 3). These plumes predominantly contain VOCs, SVOCs, and herbicides, however, they also contain lesser amounts of pesticides, PCBs, dioxins, and metals. To facilitate understanding of groundwater conditions in SA2, the plume boundaries are defined

as the 1,000 ppb groundwater contour lines. These plumes are presented in Figures 7-11 and 7-12.

Plume 1 extends approximately from the central portion of Site P to south of Sites O and S. It appears to originate east of Illinois Route 3 and moves onto SA2 in a manner consistent with the groundwater flow in the area. The northern portion of plume 1 (north of Sites R and Q) does not appear to reach the Mississippi River and the southern portion of the plume combines with the Site R plume.

Plume 2 is immediately adjacent to Site R with the north and southern boundaries immediately north and south of Site R, respectively. It appears to originate at Site R, and combined with the remnants of plume 1, apparently moves directly toward the Mississippi River.

Plume 3 is located within Site Q South with the northern boundary located approximately at the Site Q South and Central boundary and the southern boundary is located near the center of Site Q South. The origin of this plume is unclear, but appears to be located upgradient of the boundary of Site Q South. The plume does not appear to reach the Mississippi River.

7.4 GROUNDWATER MODELING

7.4.1 Design Basis for SA2IGR

Groundwater Services, Inc. (GSI) of Houston, Texas developed a groundwater model for the SA2 FFS as an analysis tool for the Site R Interim Remedy. The same modeling technology was again implemented as an analysis tool for the RI/FS performed for the entire SA2 Site. This discussion summarizes the approach and results of the study as presented in the FFS.

The SHU is the only layer used in the model that acts as a confining layer. There are no aquitards or confining layers in the MHU or DHU.

Representative constituents present in groundwater include VOCs such as benzene, chlorobenzene, acetone, and 1,2-dichloroethane and SVOCs such as phenol, 2-chloroaniline, and 2-nitrochlorobenzene. These and other related constituents are found from the water table to bedrock in all three hydrogeologic units.

The objective of this study was to determine pumping rates for two alternative designs for a groundwater barrier located between SA2 Site R and the Mississippi River: i) Groundwater

Alternative B – Physical Barrier (a "U"-shaped physical barrier together with groundwater pumping); and ii) Groundwater Alternative C – Hydraulic Barrier (groundwater pumping alone to form a hydraulic barrier). A numerical groundwater flow model, MODFLOW, was used to meet these objectives (Figures 1 through 5 in Appendix L). A numerical groundwater flow model, MODFLOW, was used to develop the required information for this study.

Model Description

The MODFLOW groundwater flow model, developed by the U.S. Geological Survey (McDonald and Harbaugh, 1988) (Attachment 2 in Appendix L), was used to simulate the movement of groundwater for baseline conditions and for various pumping scenarios.

Key MODFLOW Model Attributes, Assumptions, and Input Parameters

Key model attributes, assumptions, and input data for the MODFLOW model are listed below:

- A finite-difference grid with 60 ft by 60 ft cells in the vicinity of Site R was used with cell size gradually increasing with distance from Site R (Figure 2 in Appendix L). Adjacent model cell column and row widths were not altered more than a factor of 2.0 compared to adjacent columns (Zheng and Bennett, 1995 (Attachment 3 in Appendix L), and Spitz and Moreno, 1996 (Attachment 4 in Appendix L)). The grid aspect ratio (ratio of column width to row width) was limited between 10 and 0.1.
- Three layers were used in the model: i) an unconfined SHU with a porosity of 0.30; ii) a convertible confined/unconfined MHU; and iii) a confined DHU. Geologic descriptions and hydraulic conductivity data indicate that the SHU can serve as a semi-confining layer for the deeper hydrogeologic units. As shown in Figure 1, the potentiometric surface of the MHU extends into the SHU (Layer 1 in model), also indicated confined or semi-confined conditions. No aquitards restrict vertical groundwater flow between the MHU and DHU.
- The top and bottom elevations of the hydrogeologic units were derived from geologic cross-sections developed by URS (2001c) (Attachment 5 in Appendix L), Geraghty and Miller (date unknown) (Attachment 6 in Appendix L), and Bergstrom and Walker (1956).

- The initial hydraulic conductivity value used for the SHU (Figure 3 in Appendix L) near the site was 0.01 cm/sec, taken from modeling studies performed for the Sauget Area 1 EE/CA and RI/FS (Source Evaluation Study, Sauget Area 1, Groundwater Services, Inc., May 21, 2000) (Attachment 7 in Appendix L). This value is a conservative (High-end) estimate that is partially based on slug tests conducted at Sauget Area 1 Site I that showed a hydraulic conductivity value of 4.5×10^{-3} cm/sec.
- Hydraulic conductivity data compiled by Schicht (1965) (Attachment 8 in Appendix L) were used as the initial hydraulic conductivity in the model for the MHU and DHU (Figure 3 in Appendix L). Vertical hydraulic conductivity values were used in the model to calculate leakance terms. Data from Schicht (1965) were available to construct a detailed, spatially-varying hydraulic gradient array for the entire model area for the MHU and DHU. There were no maps available of the SHU hydraulic conductivity over the entire scale of the model.
- The SHU is assumed to have a constant hydraulic conductivity because of i) a lack of a model-wide SHU hydraulic conductivity array; and ii) the apparent small contribution to flow (transmissivity of the SHU is 80 times lower than the MHU and DHU).
- Bedrock elevations, obtained by kriging data contained in Bergstrom and Walker (1956), were imported into the model.
- The Mississippi River was modeled using MODFLOW's river package. The areal extent of each river cell is shown in the model grid in Figure 2 in Appendix L. Each river cell was assigned a river elevation (assumed constant for all river cells in the model), a bottom elevation (based on a single U.S. Corps of Engineers Bathymetric cross section near Site R (Attachment 9 in Appendix L), and a conductance term. The bathymetry of the river adjacent to Site R was assumed to extend throughout the entire model reach.
- The following bottom elevation profile was used for the river. Elevations were derived from the fourth transect from the north, as this transect was aligned with the center of Site R on the USACE bathymetry map shown in Attachment 9 in Appendix L.

Distance from Eastern Shore of River (ft)	Measured Bottom Elevation in River (ft msl)
0-60	385
60-120	380
120-180	378
180-240	375
240-300	372
300-1080	370
1080-1620	360
1620+	370

- The riverbed conductance was assumed to be 795 ft^2/day, derived from the average of monthly conductance estimates reported by Schicht (1965) for a 60 ft by 60 ft cell. Proportionally higher conductances were used for cells with larger areas.
- An average river level stage of 391 ft MSL was used for the river in the study area based on 1993 to 2001 monthly river stage data (Attachment 10 in Appendix L).
- Steady-state runs were performed, and therefore no storage values were used in the model described in the report. Based on Geraghty and Miller (1993), representative storage coefficient values range from 0.04 to 0.10.
- Constant head cells were used in the model to represent the eastern boundary of the modeled area (the bluff line) based on "steady-state" constant head elevations used in a regional groundwater flow model developed by Clark (1997) (Attachment 11 in Appendix L).
- A surface infiltration rate of 7.8 inches per year was used in the model to represent infiltration from rainfall (Schicht, 1965).
- A regional pumping center of 4,167 gpm, assumed to be withdrawn from all three layers, was established in the model to represent ongoing highway dewatering projects in the East St. Louis area (Ritchey and Schicht, 1982) (Attachment 12 in Appendix L).

- Figure 4 in Appendix L indicates that the highway dewatering has little effect on the site. Head equipotential lines are relatively parallel to the river near Site R, and do not curve north towards the pumping center until they get closer to the pumping center. Since this dewatering system is associated with Interstate 64, it is reasonable to assume that pumping will continue indefinitely. Therefore, future effects on groundwater flow at Site R due to this pumping center will continue to be the same as they are today, i.e., negligible.
- Steady-state runs were performed because results from the 1993 Geraghty and Miller modeling study (Attachment 13 in Appendix L) indicated that transient modeling resulted in only minor changes in their steady-stage model results.

Modeling Approach

Zone Budget is a water balance component of the Visual MODFLOW package that reports the exchange of groundwater between adjacent zones established by the user. To calculate the quantity of groundwater discharge to the river, river cells downgradient of Site R were assigned into two zones, one for river cells in Layer 1, and one for river cells in Layer 2 (there were no river cells in Layer 3). This represented an area 2000 ft long parallel to the riverbank and extending all the way across the river. Then, by using Zone Budget, the flow rate of affected groundwater to these zones during average flow conditions was determined.

MODFLOW Calibration

Flow calibration against water levels measured on October 25, 2001 was performed by adjusting the river level to 398.5 ft (the average river level for the 24 hrs preceding the midpoint of the sampling period) (Table 2 in Appendix L) and comparing the predicted values to the actual modeled values (Table 1 in Appendix L).

The Mississippi River stage value of 398.5 ft msl is an average of hourly river stage values between 12:00 pm on Oct. 24 and 12:00 pm on Oct. 25 (Table 2 in Appendix L). Preliminary model runs indicated that the response time for the near-river MHU and DHU to changes in Mississippi River elevation had timescales of hours (as opposed to days or weeks). Therefore, an average river elevation for the 24 hours prior to the midpoint of the sampling event on Oct. 25 was selected. Oct. 25 was selected for calibration because the data were: i) representative of recent conditions; and ii) readily available.

Shallow Hydrogeologic Unit Calibration

The initial hydraulic conductivity value used for the SHU (Layer 1 in the model) near the site was 0.01 cm/sec, taken from modeling studies performed for the Sauget Area 1 EE/CA and RI/FS. This value is a conservative (high-end) estimate that is partially based on slug tests conducted at Sauget Area 1 Site I that showed a hydraulic conductivity value of 4.5×10^{-3} cm/sec.

However, initial calibration runs showed that the predicted static water levels from Layer 1 were considerably lower than the actual values measured on Oct. 25, 2001. A better match was achieved by decreasing both the horizontal and vertical hydraulic conductivity arrays in the model. The horizontal hydraulic conductivity of Layer 1 (K_x and K_y) was reduced to 0.0005 cm/sec, and the vertical hydraulic conductivity was decreased to 1×10^{-6} cm/sec to better match observed hydraulic heads.

Additional data available suggested that this lower hydraulic conductivity of Layer 1 is appropriate. First, geologic cross sections developed for Site R by URS in 2001c (Attachment 5 in Appendix L) indicated that the SHU is comprised primarily of clay. Second, Geraghty and Miller (1993 and 1994) reported that slug test values for the SHU at SA2 Site R ranged from 9×10^{-5} cm/sec to 6×10^{-3} cm/sec in two studies, "Development of a Three-Dimensional Ground-Water Flow model for Sauget Site R, Sauget, Illinois" in 1993 and "Groundwater Flow Conditions" in 1994. Geraghty & Miller also indicated that this unit is a "low permeability zone with fine-grained silty sand deposits predominating." These studies are included in Attachments 13 and 14 in Appendix L, respectively. Third, a review of the large-scale geologic cross section of the American Bottoms prepared by Bergstrom and Walker (1956) (Attachment 1 in Appendix L) shows the upper portion of the cross section being largely comprised of fine-grained material.

Additionally, the sensitivity analysis indicates that the model is relatively insensitive to moderate changes in Layer 1 hydraulic conductivity. An increase in SHU transmissivity by factor of 10 results in a flow increase of only three gpm. Therefore, varying the hydraulic conductivity of Layer 1 to obtain better modeling results is considered appropriate.

Note that even with these changes, the match in Layer 1 was not as good as the Layer 2-3 match. However, this match was considered to be acceptable (see Figure 3 in Appendix L for final hydraulic conductivity values) because:

- The contribution of flow from Layer 1 to the river is small
- Sensitivity analysis indicated a change of only 3 gpm when the hydraulic conductivity of the SHU is increased by a factor of 10
- Upper-range transmissivity of the SHU is 425 ft^2/d (0.01 cm/sec x 15 ft thickness), 80 times less than the MHU and DHU transmissivity of 35,000 ft^2/d (0.137 cm/sec x 90 ft)
- Actual flow contribution from the SHU may be less as the saturated thickness near the river is relatively small
- It is more difficult to model an unconfined, near-surface layer than a confined layer.

Therefore, the modeling focus was on the MHU and DHU. This focus is validated by comparison of predicted versus observed water levels in water level measurement wells located at Site R (see Figure 5 in Appendix L for well locations). For the key MHU and DHU, the mean of the residual errors and root mean square are approximately 1 ft, much lower than for the SHU.

Middle and Deep Hydrogeologic Unit Calibration

The hydraulic conductivity map developed by Schicht in 1965 was used for initial values of the horizontal hydraulic conductivity for the MHU and DHU (Layers 2 and 3 in the model) (K_x and K_y; no anisotropy is assumed in the horizontal plane). Zones between lines of constant hydraulic conductivity were assumed to be arithmetic averages of the two hydraulic conductivities shown on the contour lines. For example, the initial hydraulic conductivity of the zone between the 3,000 gpd/ft^2 and the 2,500 gpd/ft^2 is assumed to be 2,750 gpd/ft^2, or 0.13 cm/sec. The zone inside the 3000 gpd/ft^2 closed contour is assumed to have a hydraulic conductivity of 3,250 gpd/ft^2, or 0.15 cm/sec. The initial estimate of vertical hydraulic conductivity (K_z) is 20% of K_x and K_y.

Initial calibration runs indicated that the hydraulic gradient between the portions of the MHU and DHUs near and under the river was greater in the model than was represented in the data.

Therefore, changes were made in the following order:

1. The zone between the 2,500 gpd/ft^2 and 3,000 gpd/ft^2 on Schicht (1965) (labeled "0.137 cm/sec" for K_x and K_y in Figure 3) was extended entirely across the River in the area west of Site R.

2. The K_x and K_y (horizontal hydraulic conductivity) of the same zone were increased from 0.13 cm/sec to 0.137 cm/sec.

Additionally, the hydraulic gradient between the MHU and DHUs was greater in the model than in the October 25, 2001 dataset. Therefore, changes were made in the following order.

1. The vertical hydraulic conductivity of all zones in both the MHU and DHUs (K_z) was increased from an initial value of 0.20 of K_x and K_y to a value of 0.50 of K_x and K_y to reduce the modeled head loss.
2. The constant head elevations on the boundary cells on the east, north, and south sides of the model were adjusted to match "steady-state" data developed by Clark (1997) (Attachment 11 in Appendix L).

In general, the potentiometric surface from the MHU (Figure 4 in Appendix L) was compared to the potentiometric surface for November 1990 reported by Schicht and Buck (1995) (Attachment 15 in Appendix L). The November 1990 potentiometric surface map was developed from data taken when the Mississippi River stage was fairly low, around 385 ft msl. This value was selected as it covered the entire model area and was relatively recent. This comparison indicated a good relative match, as the general shape and values of the predicted potentiometric surface were similar to the reported potentiometric surface (including the cone of depression caused by the highway dewatering system). The predicted values did not provide an absolute match to the observed values due to differences in river stage. Overall, the MODFLOW groundwater flow model was considered to yield a reasonable simulation of the aquifer system.

Sensitivity Analysis

Sensitivity analyses were conducted for the following parameters: recharge (high and low), hydraulic conductivity in all three layers and in layer 1 alone (high and low), river stage, and overall conductivity. The range that was varied for each parameter was based on ranges in the underlying data for each parameter used in the sensitivity analysis.

The table below summarizes the discharge from Site R to the river when various parameters are altered. Conclusions that can be drawn from this sensitivity analysis are:

- Estimated groundwater discharge to the Mississippi River is insensitive to the hydraulic conductivity of the SHU

- Underestimation or overestimation of the hydraulic conductivity of all three hydrogeologic units by a factor of 1.5 could result in groundwater discharges to the Mississippi River ranging from 436 to 684 gpm, respectively
- A decrease in recharge of 2.5 inches/yr or an increase in recharge of 2.1 inches/yr could results in groundwater discharges to the Mississippi River ranging from 466 to 632 gpm, respectively
- An increase in river stage of 9.8 ft or a decrease in river stage of 7.9 ft could result in groundwater; discharges to the Mississippi River ranging from 303 to 724 gpm
- Estimated groundwater discharge to the Mississippi River is insensitive to the conductance of the river bottom.

Sensitivity Run Description	Flow Rate of Affected Groundwater to River (gpm)
Baseline Case	535
HIGHER Hydraulic Conductivity In All Three Layers (K_x, K_y, and K_z shown in Fig. 3 in Appendix L increased by factor of 1.5)	684
LOWER Hydraulic Conductivity In All Three Layers (K_x, K_y, and K_z shown in Fig. 3 in Appendix L reduced by factor of 1.5)	436
HIGHER Hydraulic Conductivity In Shallow Unit Only (K_x, K_y, and K_z shown in Fig. 3 in Appendix L increased by factor of 10)	538
LOWER Hydraulic Conductivity in Shallow Unit Only (K_x, K_y, and K_z shown in Fig. 3 in Appendix L reduced by factor of 10)	535
HIGHER Recharge: Recharge Increased from 7.8 inches/yr to 9.9 inches per year	632
LOWER Recharge: Recharge Decreased from 7.8 inches/yr to 6.3 inches per yr	466
HIGHER River Stage: River Stage Increased from 391 ft msl to 400.8 ft msl (the high monthly average flow)	303
LOWER River Stage: River Stage Decreased from 391 ft msl to 383.1 ft msl (the low monthly average flow)	724
HIGHER River Conductance: River Conductance multiplied by 2.7	546
LOWER River Conductance: River Conductance divided by 1.4	531

Model Limitations

The model has the following key limitations:

- The SHU is assumed to have a constant hydraulic conductivity;
- The river is simulated with idealized cross section and river bottom conductance values;
- Only one parameter was changed at a time during the sensitivity analysis, and therefore the modeling analysis does not account for any combined effects of parameters that might be changed.

Modeling Results

The modeling analysis indicated that the flow rate of affected groundwater from the water-bearing units underlying Site R to the Mississippi River during average river level conditions is 535 gpm. As expected, the sensitivity analysis indicated that this value changes if key input data are changed. The most sensitive parameter was river stage, and when the high monthly average river stage (401 ft msl) is used in the base case model, the flow rate of affected groundwater from Site R to the river decreases to 303 gpm. When the low monthly average river stage (383 ft msl) is used in the base case model, the flow rate of affected groundwater from Site R to the river increases to 724 gpm.

The modeling results are based on the best estimates of input parameters, model discretization, boundary condition, and other factors. The sensitivity analysis is based on changing one key parameter at a time, and does not consider complex effects of river stage, recharge, and other boundary conditions. As with any groundwater recovery system, more accurate information can be obtained from installing, operating, and analyzing the performance data from the pumping system.

KEY POINT: MODELING RESULTS

The modeling results indicate that the flow rate of affected groundwater to the river is **535 gpm** during typical aquifer conditions and average river stage (391 ft msl). The sensitivity analysis indicates that this flow rate decreases when the river stage is high and increases when the river stage is low (when all other factors remain constant). When the monthly average high river stage and monthly average low river stage are used, the modeling indicates that the flow rate of affected groundwater to the river ranges from **303 gpm to 724 gpm**.

Design Basis: Alternative B – Physical Barrier

A fully-penetrating, "U"-shaped physical barrier will extending along the downgradient portion of Site R, with side walls extending upgradient along the edges of Site R, will prevent inflow of clean groundwater into pumping wells located within the "U" shaped barrier. Therefore, the design flow rate of the pumping wells used in Groundwater Alternative B – Physical Barrier system is equal to the flow rate of affected groundwater to the river.

- Higher River Stage (monthly average high river stage of 401 ft msl): 303 gpm
- Average River Stage (monthly average river stage of 391 ft msl): 535 gpm
- Lower River Stage (monthly average low river stage of 383 ft msl): 724 gpm

Three pumping wells will provide a reliable extraction system. Performance monitoring should be performed to ensure that this pumping system effectively captures groundwater flowing into the "U"-shaped barrier wall.

KEY POINT: DESIGN BASIS FOR ALTERNATIVE B – PHYSICAL BARRIER

A physical barrier with wingwalls located on the downgradient side of Site R will prevent inflow of clean groundwater into the pumping wells associated with this alternative. Therefore, the design basis for Alternative B – Physical Barrier is for the pumping system associated with this alternative to pump at a rate equivalent to the flow rate of affected groundwater flow from Site R and other upgradient sources to the river. Based on the modeling results, the total pumping rate for this alternative is:

- **303 gpm (at Higher river stage)**
- **535 gpm (at Average river stage)**
- **724 gpm (at Lower river stage)**

Three pumping wells will provide a reliable extraction system.

Design Basis: Alternative C – Hydraulic Barrier

Based on uniform-flow capture zone analysis methods (see Attachment 16, pg. 127 in Appendix L), a relationship between Darcy flow through a vertical plane and the pumping rate required to capture this flow can be made. As shown on page 127 of Attachment 16 in Appendix L, a

pumping well has a capture width when X = 0 (i.e., at a cross section perpendicular to groundwater flow at the well itself) of:

$$Y = Q / (2 \cdot T \cdot i)$$

Where:

Y = Distance between Dividing Streamlines at the Line of Wells ("Capture zone width") (length)

Q = Pumping rate of well (length^3 per time)

T = Transmissivity of aquifer (length^2 per time)

i = Regional hydraulic gradient (dimensionless)

Rearranging this equation shows that

$$Q = Y \cdot 2 \cdot T \cdot i$$

The Darcy groundwater flow rate (Q_d) through this cross section equals:

$$Q_d = Y \cdot T \cdot i$$

Therefore, the ratio of Q (the flow rate required to achieve a capture zone width Y) to Q_d (the Darcy flow rate through a vertical plan with width Y) is equal to 2. In other words, to capture the flow in a vertical plan located at the pumping well and perpendicular to groundwater flow, the well must pump at twice the Darcy groundwater flow rate.

This basic groundwater capture zone relationship (as derived in Attachment 16) shows that the design flow rate of the Site R hydraulic barrier system must be twice the Darcy flow rate from Site R to the river, or 2 x 535 gpm = **1070 gpm** at average river stage conditions (391 ft msl). (Note that the number of wells does not change this basic relationship, as the capture zone width is independent of the number of wells as shown on page 128 of Attachment 16.)

Attachment 16 in Appendix L also indicates that this relationship is a conservative solution because this method does not lead to "an optimal solution" (see page 127 of Attachment 16 in Appendix L). Therefore, this design approach will overestimate the pumping rate required for

capture. However, in a situation where groundwater discharging to surface water is causing an unacceptable impact, a conservative approach is appropriate.

In summary, the design flow rate of the pumping wells used in the Groundwater Alternative C – Hydraulic Barrier system is equal to twice the flow rate of affected groundwater from Site R to the river.

- Higher River Stage (monthly average high river stage of 401 ft msl): 606 gpm
- Average River Stage (monthly average river stage of 391 ft msl): 1070 gpm
- Lower River Stage (monthly average low river stage of 383 ft msl): 1448 gpm

Three pumping wells will provide a reliable system for Alternative C with only minimal inflow from the river (see Figure 5 in Appendix L for well locations). Two of the wells are located over 350 ft from the river, and influx from the river is unlikely. The third well (Well 3 on Figure 5 in Appendix L) is located only 150 ft from the river, and some inflow might occur. To manage the inflow problem, Wells 1 and 2 can be pumped at higher rates and Well 3 at a lower rate. Performance monitoring should be performed to ensure that this pumping system effectively captures groundwater crossing the hydraulic barrier.

KEY POINT: DESIGN BASIS FOR ALTERNATIVE C – HYDRAULIC BARRIER

Based on analytical capture zone relationships, the hydraulic barrier system must pump at twice the flow rate of affected groundwater from Site R to the river. Using the modeling results, the total pumping rate for this alternative is:

- **606 gpm (at Higher river stage)**
- **1070 gpm (at Average river stage)**
- **1448 gpm (at Lower river stage)**

A three-well pumping system will provide a reliable system. Inflow from the river can be managed by pumping the three wells at different rates.

7.4.2 Groundwater Modeling for 2003 Feasibility Study

A groundwater modeling effort was conducted to develop data used in the evaluation of remedial alternatives presented in the feasibility study (Section 9.0). The groundwater modeling was conducted by Groundwater Services, Inc. (GSI) of Houston, Texas.

The purpose of the modeling was to develop conceptual design parameters such as estimated groundwater extraction rates and well spacing for use in the evaluation of remedial alternatives for groundwater. In addition, the evaluation also included use of a simple source decay model to develop estimates of cleanup times for various remedial alternatives evaluated in the streamlined feasibility study. Technical details relevant to the modeling effort is included in Appendix M.

The following sections summarize the tasks included in the modeling effort.

MODFLOW Model Calibration

The MODFLOW groundwater model developed for the Sauget Area 2 Focused Feasibility Study (Volume 2, Interim Groundwater Remedy Design Basis, Solutia Inc., March 2002) was refined and calibrated for the entire SA2 Site. The existing groundwater flow model was originally developed as an analysis tool for the Site R interim remedy. Therefore, the original model calibration effort was focused in the vicinity of Site R to optimize simulation of conditions near Site R. The objective of this task was to verify that the current model calibration was appropriate to reasonably simulate conditions across all of SA2 Site.

Flow calibration against water levels measured on June 9, 2003 was performed by adjusting the Mississippi River level to the actual level on June 9, 2003 and comparing the model-predicted values to the actual measured values for nine piezometers, each screened in the shallow, middle, and deep hydrogeologic units. Overall, the MODFLOW groundwater flow model was considered to yield a reasonable simulation of the aquifer system and all parameters used for the initial Interim Groundwater Remedy Design Basis Report were retained.

Flow Rate Estimation

The MODFLOW groundwater model was used to develop estimates of groundwater extraction rates for the five remedial alternatives presented in the feasibility study. The estimated

groundwater extraction rates and well spacing are described in Section 9.0 and in the technical memorandum in Appendix M.

Remediation Timeframe

The evaluation of cleanup times was based on the methodology presented in the Source Evaluation Study (GSI, 2001a) developed for the groundwater feasibility study included in the Sauget Area 1 EE/CA (Roux Associates, 2001).

The available groundwater data for SA2 Sites were used to develop planning-level constituent source mass estimates and mass flux estimates for Sites O, P, Q, R, and S. Using the estimated source mass and mass flux, a simple source decay model was used to develop planning level estimates of the source lifetimes under natural groundwater flow and attenuation conditions. A source decay coefficient was developed and used to estimate the decrease in cleanup time that would result from an increased groundwater flow rate through the source zones.

SECTIONEIGHT Risk Assessments

November 20, 2000, the SA2SG Potentially Responsible Parties (PRPs) signed an Administrative Order on Consent (AOC), Docket Number V-W-01-C-622, to perform a RI/FS at SA2 O, P, Q, R, and S. The USEPA signed the AOC on November 24, 2000. As part of the RIFS process, a human health risk assessment (HHRA, dated August 31, 2002) and a baseline ecological risk assessment (BERA, dated August 2003) were performed and submitted as separate documents to USEPA. This information presented in this section provides the results of HHRA and BERA. A complete discussion of these risk assessments including all tables, figures, and appendices, can be found in the documents entitled Human Health Risk Assessment and Draft Ecological Risk Assessment.

8.1 HUMAN HEALTH RISK ASSESSMENT

The HHRA was conducted to satisfy the AOC, as well as to be compliant with the National Contingency Program (NCP) (USEPA, 1990). The HHRA was conducted in accordance with USEPA-approved Human Health Risk Assessment Work Plan (HHRA Work Plan) dated May 25, 2001 (including September 2001 and May 2002 revised pages), which was submitted as Section 11 of Volume 1 of the SSP.

The HHRA was conducted using data from environmental samples collected from the study area in accordance with the USEPA-approved SSP. The SSP for SA2 was designed to investigate two major areas of the SA2 study area (the media sampled in each are identified in parentheses):

- The Sites O, P, Q, R, and S (waste, soil, groundwater, leachate, ambient air – all sites; sediment, surface water, fish tissue – Site Q Pond only)
- Mississippi River adjacent to the Sites (sediment, surface water and fish tissue).

The baseline HHRA has been conducted in accordance with the four-step paradigm for human health risk assessments developed by USEPA (USEPA, 1989a). The risk assessment results are summarized by step below.

Data Evaluation and Hazard Identification

The purpose of the data evaluation and hazard identification process is two-fold: 1) to evaluate the nature and extent of release of constituents present at the site; and 2) to select a subset of these constituents identified as Constituents of Potential Concern (COPCs) for quantitative

evaluation in the risk assessment. This step of the risk assessment involves compiling and summarizing the data for the risk assessment, and selecting COPCs based on a series of screening steps. Several factors were considered in selecting COPCs, including natural background, frequency of detection, and toxicity, and essential nutrient status. COPC selection for evaluation in the quantitative HHRA was performed on each of the following media:

- Surface soil (0 to 6 inches bgs)
- Combined soil (combined surface, subsurface (6 feet bgs), and waste)
- Shallow groundwater, mid groundwater, and leachate
- Surface water
- Sediment
- Fish fillet.

Screening was also performed for a separate analysis of deep groundwater and ambient air, which was not included in the quantitative HHRA. An evaluation of the soil-to-groundwater pathway was also performed.

COPCs were identified in Site O, Site O (North), Site P, Site Q (North), Site Q (Central), Site Q (South), and Site S surface soils. No COPCs were identified in Site R surface soils. COPCs in combined soils were identified in all sites for the construction worker direct-contact pathway. COPCs in combined soils for the ambient air pathway (non-excavation scenarios) were identified in all Sites with the exception of Site Q (Central).

The selection of COPCs for groundwater/leachate was conducted on a location-by-location basis. Wells with screen intervals or sample collection depths between 0 and 30 feet bgs were included in the evaluation. Because groundwater in the area is not used a source of drinking water, exposure to COPCs in groundwater could occur due to either volatilization of COPCs into indoor or outdoor air, or contact with COPCs in groundwater exposed in an excavation trench. Per the HHRA Work Plan, a 15-foot bgs excavation depth is assumed (shallow groundwater, leachate). Moreover, volatilization from groundwater through the soil column to indoor and/or outdoor air is generally assumed to occur at depths of up to 30 feet bgs (shallow groundwater, mid groundwater/leachate). Based on these considerations, a total of 13 groundwater sampling locations were included in the evaluation. Of the 13 groundwater sampling locations and three

leachate wells evaluated, COPCs were identified in only three groundwater locations and in all three leachate wells. Arsenic was identified as the only COPC in Mississippi River sediment; no COPCs were identified in Mississippi River surface water. No COPCs were identified in Site Q Pond sediment. Several COPCs were identified in the Site Q Pond surface water. COPCs were identified in fish fillet samples from both the Mississippi River and the Site Q Ponds.

Dose-Response Assessment

The purpose of the dose-response assessment is to identify the types of adverse health effects a constituent may potentially cause, and to define the relationship between the dose of a constituent and the likelihood or magnitude of an adverse effect (response) (USEPA, 1989a). Adverse effects are classified by USEPA as potentially carcinogenic or noncarcinogenic (i.e., potential effects other than cancer). Dose-response relationships are defined by USEPA for oral exposure and for exposure by inhalation. Oral toxicity values are also used to assess dermal exposures, with appropriate adjustments, because USEPA has not yet developed values for this route of exposure. Combining the results of the toxicity assessment with information on the magnitude of potential human exposure provides an estimate of potential risk. Sources of the published toxicity values in this risk assessment include USEPA's IRIS database (USEPA, 2003b), HEAST (USEPA, 1997c), and the USEPA NCEA in Cincinnati, Ohio.

Exposure Assessment

The purpose of the exposure assessment is to predict the magnitude and frequency of potential human exposure to each of the COPCs retained for quantitative evaluation in the HHRA. The first step in the exposure assessment process is the characterization of the setting of the site and surrounding area. Current and potential future site uses and potential receptors (i.e., people who may contact the impacted environmental media of interest) are then identified. Potential exposure scenarios identifying appropriate environmental media and exposure pathways for current and potential future site uses and receptors are then developed. Those potential exposure pathways for which COPCs are identified and are judged to be complete are evaluated quantitatively in the risk assessment. Both Reasonable Maximum Exposure (RME) and Most Likely Exposure (MLE) scenarios were evaluated for each receptor in the HHRA.

To guide identification of appropriate exposure pathways and receptors for evaluation in the risk assessment, a conceptual site model (CSM) for human health was developed. The purpose of the

CSM is to identify source areas, potential migration pathways of constituents from source areas to environmental media where exposure can occur, and to identify potential human receptors based on current and future site uses. Based on the CSM, the following receptors and pathways were evaluated in the HHRA:

- On-site indoor industrial worker - potential exposure to COPCs via inhalation of volatile constituents present in indoor air due to vapor intrusion from groundwater/leachate.

- On-site outdoor industrial worker - potential exposure to COPCs in surface soil via incidental ingestion, dermal contact, inhalation of non-volatile COPCs that may be suspended as dusts from surface soils, and to COPCs that may volatilize into outdoor air from underlying groundwater and from soils (combined surface soil, subsurface soil, and waste).

- Trespassing teenager - potential exposure to COPCs in surface soil via incidental ingestion, dermal contact, inhalation of non-volatile COPCs that may be suspended as dusts from surface soils, and to COPCs that may volatilize into outdoor air from underlying groundwater and from soils (combined surface soil, subsurface soil, and waste), and to COPCs in surface water and sediment from the Site Q Pond and the Mississippi River (note, no COPCs were identified in Site Q Pond sediment).

- On-site construction/utility worker - potential exposure to COPCs in soils (combined surface soil, subsurface soil, waste) via incidental ingestion, dermal contact, inhalation of volatile emissions and particulates suspended during excavation activity, and to COPCs in shallow groundwater and leachate via incidental ingestion and dermal contact, and via inhalation of COPCs volatilized from standing water in an excavation trench.

- Recreational fisher - potential exposure to COPCs in surface water, sediment, and fish fillet from the Site Q Pond and the Mississippi River (note, no COPCs were identified in Site Q Pond sediment).

Exposure Point Concentrations (EPCs) were derived using both measurement (analytical) data collected during the field investigation, and modeled data (e.g., volatilization to ambient and indoor air).

Risk Characterization

The potential risk to human health associated with potential exposure to COPCs in environmental media at the site is evaluated in this step of the risk assessment process. Risk characterization is the process in which the dose-response information is integrated with quantitative estimates of human exposure derived in the Exposure Assessment. The result is a quantitative estimate of the likelihood that humans will experience any adverse health effects given the exposure assumptions made. Two general types of health risk are characterized for each potential exposure pathway considered: potential carcinogenic risk and potential noncarcinogenic hazard. Carcinogenic risk is evaluated by averaging exposure over a normal human lifetime, which, based on USEPA guidance (1989), is assumed to be 70 years. Noncarcinogenic hazard is evaluated by averaging exposure over the total exposure period.

The potential carcinogenic risk for each exposure pathway is calculated for each receptor. In current regulatory risk assessment, it is assumed that cancer risks are additive or cumulative. Pathway and area-specific risks were summed to estimate the total site potential cancer risk for each receptor. The total site cancer risks for each receptor group are compared to the USEPA's target risk range of 10-4 to 10-6. Any COPC that causes an exceedance of the 10-4 risk level for a particular receptor is designated a COC. Both RME and MLE results are considered in the identification of COCs.

The target risk levels used for the identification of COCs are based on USEPA guidance and Illinois Tiered Approach to Corrective Action Objectives (TACO) guidance. Specifically, USEPA provides the following guidance (USEPA, 1991):

> "Where the cumulative carcinogenic site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10-4, and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts." and,
>
> "The upper boundary of the risk range is not a discrete line at 1 x 10-4, although EPA generally uses 1 x 10-4 in making risk management decisions. A specific risk estimate around 10-4 may be considered acceptable if justified based on site-specific conditions."

The Illinois Environmental Protection Agency (IEPA) provides the following summary for the evaluation of cumulative risk for carcinogens (IEPA, 2002c, Fact Sheet 13: Mixture Rule):

> "The cumulative risk of carcinogenic contaminants attacking the same target must not exceed 1 in 10,000 [10-4]. Therefore, the risk from all on-site similar acting carcinogens must be added together. If this cumulative risk level is greater than 1 in 10,000, corrective action must be taken to reach an acceptable risk level."

The potential for exposure to a constituent to result in adverse noncarcinogenic health effects is estimated for each receptor by comparing the dose for each COPC with the RfD for that COPC. The resulting ratio, which is unitless, is known as the HQ for that constituent. The target HQ is defined as an HQ of less than or equal to one (USEPA, 1989). When the HQ is less than or equal to 1, the RfD has not been exceeded, and no adverse noncarcinogenic effects are expected. If the HQ is greater than 1, there may be a potential for adverse noncarcinogenic health effects to occur; however, the magnitude of the HQ cannot be directly equated to a probability or effect level. HQs for a given pathway are summed to provide an HI. Pathway HIs are summed to provide a total receptor HI. When the HI is less than 1, the target has not been exceeded, and no adverse noncarcinogenic effects are expected. This initial HI summation assumes that all the COPCs are additive in their toxicity, and is considered only a screening step as additive toxicity may not be correct. If the HI is greater than 1, further evaluation is necessary to determine if the COPCs are additive in toxicity. This evaluation is termed a toxic endpoint analysis. Any COPC that causes an exceedance of a toxic-endpoint specific HI of 1 was designated a COC.

Risk Assessment Results

As previously stated, COPCs that significantly contribute to an exceedance of the 10-4 risk level are identified as COCs. COPCs that significantly contribute to an exceedance of the target endpoint HI of 1 are also identified as COCs. Table ES-1 presents the COCs by site and receptor. Figure ES-1 indicates the locations of the COCs. COCs were identified for the following areas and receptors:

Site	Receptor
Site O	Outdoor Industrial Worker Construction/Utility Worker
Site O (North)	Outdoor Industrial Worker Construction/Utility Worker Trespassing Teenager
Site Q (North)	Construction/Utility Worker
Site Q (Pond)	Recreational Fisher
Site R	Outdoor Industrial Worker Construction/Utility Worker
Site S	Outdoor Industrial Worker Construction/Utility Worker Trespassing Teenager

Details regarding which COCs were identified for each area/receptor are provided in Table ES-1. The majority of the areas where COCs were identified are not currently used, or are isolated, as described below. Exposure information relevant to the receptors for which COCs were identified is also discussed.

Site O and Site O (North) are located in an isolated area and are not currently used. Former wastewater treatment lagoons in the area are covered and vegetated, and the vegetation is mowed periodically during the warmer months of the year. Therefore, the potential risks presented above for workers represent the future scenario (the only activity under the current scenario is mowing, which is limited in frequency and duration). The receptor assumptions are extremely conservative for this area, as it is unlikely that an outdoor industrial worker would access the site for 190 days per year. It is also unlikely that construction/utility work would occur in this area for the assumed 40 day period (RME) or 20 day period (MLE). Due to the isolated nature of the site, it is unlikely that trespassers would enter the site as frequently as assumed (26 days RME, 13 days MLE).

A 10-acre site on Site Q (North) is currently used by River City Landscape Supply as a bulk storage terminal for lawn and garden products. Raw landscape products such as mulch, rock and soil are processed and packed on this portion of the site. Access to some portions of the site is restricted by fencing and gates. Other parts of the site have unrestricted access. As noted above,

potential risk SA2 HHRA- RI/FS exceedances for this area were identified for the construction/utility worker, not for the outdoor industrial worker. Therefore, these are potential risks for a future construction/utility worker, as there is no current excavation work in this area.

Fishing can occur in the Site Q Ponds; however, fish are only present as a result of flood events. After the ponds dry out, fish are not reintroduced until another flood event, although water may collect in the ponds from precipitation. It is therefore extremely unlikely that a recreational fisher would be able to obtain 22 fish meals per year from the Site Q Ponds, as assumed by the RME scenario.

Site R is a closed industrial-waste disposal area owned by Solutia, Inc. The site is not currently used. Access to Site R is restricted by fencing and is monitored by Solutia plant personnel. Therefore, the potential risks presented above represent the future scenario. It is unlikely that an outdoor industrial worker will access the site 190 days per year in the future. Excavation is not allowed at Site R unless a permit is obtained from the plant and appropriate measures are taken to protect workers undertaking intrusive activities. Therefore, the risk assessment for the construction/utility worker represents a very conservative scenario.

Site S is an unused, 1-acre area. The northern portion of the site is grassed, and its southern portion is covered with gravel and fenced. Therefore, the potential risks presented above for workers represent the future scenario only, and the exposure frequency assumptions are very conservative given the small size of the site. Additionally, due to the fencing of portions of the site and the small size, trespassers are unlikely to access the site frequently.

In summary, several areas of SA2 were found to pose risks above the risk management benchmarks. However, it should be noted that numerous conservative assumptions were made in the risk assessment, and actual risks are likely to be lower than predicted in this report.

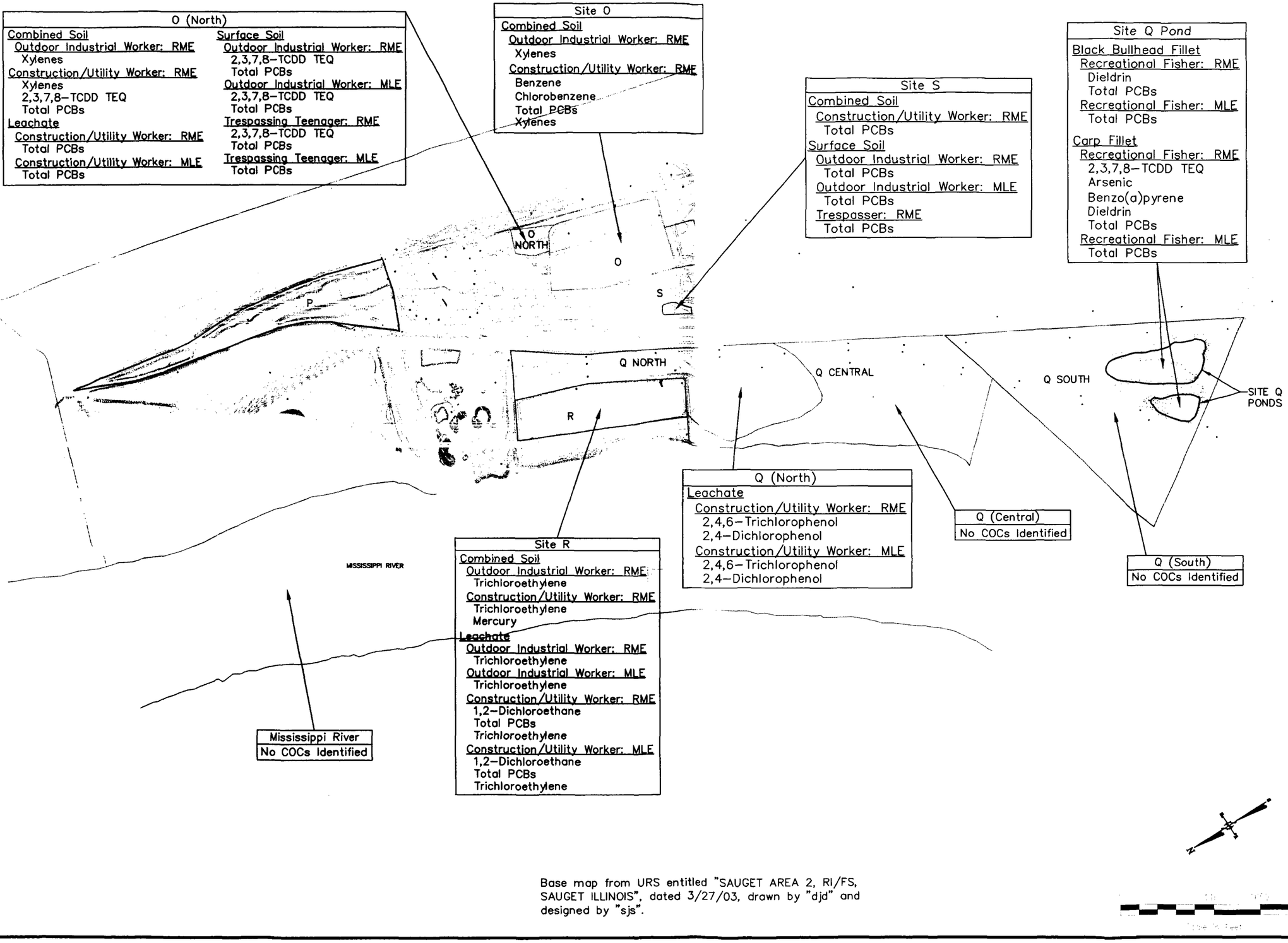
TABLE ES-1
SUMMARY OF CONSITUENTS OF CONCERN (COCs)
HUMAN HEALTH RISK ASSESSMENT
SAUGET AREA 2 RI/FS
SAUGET, ILLINOIS

Site	Receptor	Scenario	COC	Cancer (a) Potential Risk	Non-Cancer (a) HQ	Endpoint	Medium	Pathway	EPC	Units
O	Outdoor Industrial Worker	RME	Xylenes	ND	3.23	Neurological	Combined soil	Inhalation	14000	mg/kg
O	Construction/Utility Worker	RME	Chlorobenzene	ND	1	Liver	Combined soil	Inhalation	760	mg/kg
O	Construction/Utility Worker	RME	Xylenes	ND	14.2	Neurological	Combined soil	Inhalation	14000	mg/kg
O	Construction/Utility Worker	RME	Benzene	NCOC	3.16	Immune	Combined soil	Inhalation	500	mg/kg
O	Construction/Utility Worker	RME	PCBs	NCOC	2.53	Immune, skin, eye	Combined soil	Ingestion/Dermal	298	mg/kg
O North	Outdoor Industrial Worker	RME	PCBs	1.66E-04	11.6	Immune, skin, eye	Surface soil	Ingestion/Dermal	709	mg/kg
O North	Outdoor Industrial Worker	RME	2,3,7,8-TCDD TEQ	4.59E-04	ND	ND	Surface soil	Ingestion/Dermal	0.0508	mg/kg
O North	Outdoor Industrial Worker	RME	Xylenes	ND	1.23	Neurological	Combined soil	Inhalation	3900	mg/kg
O North	Outdoor Industrial Worker	MLE	PCBs	NCOC	7.27	Immune, skin, eye	Surface soil	Ingestion/Dermal	709	mg/kg
O North	Outdoor Industrial Worker	MLE	2,3,7,8-TCDD TEQ	8.32E-05	ND	ND	Surface soil	Ingestion/Dermal	0.0508	mg/kg
O North	Construction/Utility Worker	RME	2,3,7,8-TCDD TEQ	1.15E-04	ND	ND	Combined soil	Ingestion/Dermal	0.0508	mg/kg
O North	Construction/Utility Worker	RME	Xylenes	ND	3.95	Neurological	Combined soil	Inhalation	3900	mg/kg
O North	Construction/Utility Worker	RME	PCBs	NCOC	25.7	Immune, skin, eye	Combined soil	Ingestion/Dermal	3030	mg/kg
O North	Construction/Utility Worker	RME	PCBs	NCOC	2.81	Immune, skin, eye	Leachate	Ingestion/Dermal	0.055	mg/L
O North	Construction/Utility Worker	MLE	PCBs	NCOC	5.48	Immune, skin, eye	Combined soil	Ingestion/Dermal	1780	mg/kg
O North	Construction/Utility Worker	MLE	PCBs	NCOC	1.4	Immune, skin, eye	Leachate	Ingestion/Dermal	0.055	mg/L
O North	Trespassing Teenager	RME	PCBs	NCOC	4.86	Immune, skin, eye	Surface soil	Ingestion/Dermal	709	mg/kg
O North	Trespassing Teenager	RME	2,3,7,8-TCDD TEQ	8.62E-05	ND	ND	Surface soil	Ingestion/Dermal	0.0508	mg/kg
O North	Trespassing Teenager	MLE	PCBs	NCOC	1.33	Immune, skin, eye	Surface soil	Ingestion/Dermal	709	mg/kg
Q North	Construction/Utility Worker	RME	2,4,6-Trichlorophenol	NCOC	8.43	Reproductive	Leachate	Ingestion/Dermal	12.5	mg/L
Q North	Construction/Utility Worker	RME	2,4-Dichlorophenol	ND	1.82	Immune	Leachate	Ingestion/Dermal	170	mg/L
Q North	Construction/Utility Worker	MLE	2,4,6-Trichlorophenol	NCOC	4.21	Reproductive	Leachate	Ingestion/Dermal	12.5	mg/L
Q North	Construction/Utility Worker	MLE	2,4-Dichlorophenol	ND	0.907	Immune	Leachate	Ingestion/Dermal	170	mg/L
Q Pond	Recreational Fisher	RME	PCBs	3.79E-04	22.1	Immune, skin, eye	Black bullhead fillet	Ingestion	3.87	mg/kg
Q Pond	Recreational Fisher	RME	Dieldrin	7.84E-05	NCOC	NCOC	Black bullhead fillet	Ingestion	0.1	mg/kg
Q Pond	Recreational Fisher	MLE	PCBs	NCOC	2.76	Immune, skin, eye	Black bullhead fillet	Ingestion	3.87	mg/kg
Q Pond	Recreational Fisher	RME	PCBs	9.80E-04	57.1	Immune, skin, eye	Carp fillet	Ingestion	10	mg/kg
Q Pond	Recreational Fisher	RME	Dieldrin	1.49E-04	NCOC	NCOC	Carp fillet	Ingestion	0.19	mg/kg
Q Pond	Recreational Fisher	RME	2,3,7,8-TCDD TEQ	1.35E-04	ND	ND	Carp fillet	Ingestion	1.84E-05	mg/kg
Q Pond	Recreational Fisher	RME	Benzo(a)pyrene	6.44E-05	ND	ND	Carp fillet	Ingestion	0.18	mg/kg
Q Pond	Recreational Fisher	RME	Arsenic	6.02E-05	NCOC	NCOC	Carp fillet	Ingestion	0.82	mg/kg
Q Pond	Recreational Fisher	MLE	PCBs	NCOC	7.14	Immune, skin, eye	Carp fillet	Ingestion	10	mg/kg
R	Outdoor Industrial Worker	RME	Trichlororethylene	6.12E-04	NCOC	NCOC	Combined soil	Inhalation	2200	mg/kg
R	Outdoor Industrial Worker	RME	Trichlororethylene	6.93E-04	NCOC	NCOC	Leachate	Inhalation	150	mg/L
R	Outdoor Industrial Worker	MLE	Trichlororethylene	1.34E-04	NCOC	NCOC	Leachate	Inhalation	150	mg/L
R	Construction/Utility Worker	RME	Trichlororethylene	4.33E-05	1.22	Liver	Combined soil	Ingestion/Dermal	2200	mg/kg
R	Construction/Utility Worker	RME	Trichlororethylene	7.13E-04	14.43	Liver, Neurological	Leachate	Ingestion/Dermal/Inhalation	150	mg/L
R	Construction/Utility Worker	RME	PCBs	1.17E-04	204	Immune, skin, eye	Leachate	Ingestion/Dermal	3.98	mg/L
R	Construction/Utility Worker	RME	1,2-Dichloroethane	5.54E-05	8.42	Liver, kidney, GI, and skin	Leachate	Inhalation	50	mg/L
R	Construction/Utility Worker	RME	Mercury	ND	0.747	Immune	Combined soil	Ingestion/Dermal	699	mg/kg
R	Construction/Utility Worker	MLE	Trichlororethylene	2.19E-04	5.76	Liver	Leachate	Inhalation	150	mg/L
R	Construction/Utility Worker	MLE	PCBs	NCOC	102	Immune, skin, eye	Leachate	Ingestion/Dermal	3.98	mg/L
R	Construction/Utility Worker	MLE	1,2-Dichloroethane	NCOC	2.53	Liver, kidney, GI, and skin	Leachate	Inhalation	50	mg/L

TABLE ES-1
SUMMARY OF CONSITUENTS OF CONCERN (COCs)
HUMAN HEALTH RISK ASSESSMENT
SAUGET AREA 2 RI/FS
SAUGET, ILLINOIS

Site	Receptor	Scenario	COC	Cancer (a) Potential Risk	Non-Cancer (a) HQ	Endpoint	Medium	Pathway	EPC	Units
S	Outdoor Industrial Worker	RME	PCBs	2.37E-04	16.6	Immune, skin, eye	Surface soil	Ingestion/Dermal	1010	mg/kg
S	Outdoor Industrial Worker	MLE	PCBs	NCOC	5.17	Immune, skin, eye	Surface soil	Ingestion/Dermal	504	mg/kg
S	Construction/Utility Worker	RME	PCBs	NCOC	8.56	Immune, skin, eye	Combined soil	Ingestion/Dermal	1010	mg/kg
S	Trespassing Teenager	RME	PCBs	NCOC	6.91	Immune, skin, eye	Surface soil	Ingestion/Dermal	1010	mg/kg

Notes:
EPC - Exposure point concentration.
GI - Gastrointestinal.
HQ - Hazard Quotient.
MLE - Most Likely Exposure.
NCOC - Not a constituent of concern via this pathway.
ND - No Dose-Response value for this pathway.
PCBs - Polychlorinated Biphenyls.
RME - Reasonable Maximum Exposure.
TCDD-TEQ - 2,3,7,8-Tetrachlorodibenzo-p-dioxin Toxic Equivalents Concentration.
(a) - Only constituents driving a risk exceedance are presented on this table.



O (North)

Combined Soil
- Outdoor Industrial Worker: RME
  - Xylenes
- Construction/Utility Worker: RME
  - Xylenes
  - 2,3,7,8–TCDD TEQ
  - Total PCBs

Leachate
- Construction/Utility Worker: RME
  - Total PCBs
- Construction/Utility Worker: MLE
  - Total PCBs

Surface Soil
- Outdoor Industrial Worker: RME
  - 2,3,7,8–TCDD TEQ
  - Total PCBs
- Outdoor Industrial Worker: MLE
  - 2,3,7,8–TCDD TEQ
  - Total PCBs
- Trespassing Teenager: RME
  - 2,3,7,8–TCDD TEQ
  - Total PCBs
- Trespassing Teenager: MLE
  - Total PCBs

Site O

Combined Soil
- Outdoor Industrial Worker: RME
  - Xylenes
- Construction/Utility Worker: RME
  - Benzene
  - Chlorobenzene
  - Total PCBs
  - Xylenes

Site S

Combined Soil
- Construction/Utility Worker: RME
  - Total PCBs

Surface Soil
- Outdoor Industrial Worker: RME
  - Total PCBs
- Outdoor Industrial Worker: MLE
  - Total PCBs
- Trespasser: RME
  - Total PCBs

Site Q Pond

Black Bullhead Fillet
- Recreational Fisher: RME
  - Dieldrin
  - Total PCBs
- Recreational Fisher: MLE
  - Total PCBs

Carp Fillet
- Recreational Fisher: RME
  - 2,3,7,8–TCDD TEQ
  - Arsenic
  - Benzo(a)pyrene
  - Dieldrin
  - Total PCBs
- Recreational Fisher: MLE
  - Total PCBs

Q (North)

Leachate
- Construction/Utility Worker: RME
  - 2,4,6–Trichlorophenol
  - 2,4–Dichlorophenol
- Construction/Utility Worker: MLE
  - 2,4,6–Trichlorophenol
  - 2,4–Dichlorophenol

Q (Central)

No COCs Identified

Q (South)

No COCs Identified

Site R

Combined Soil
- Outdoor Industrial Worker: RME
  - Trichloroethylene
- Construction/Utility Worker: RME
  - Trichloroethylene
  - Mercury

Leachate
- Outdoor Industrial Worker: RME
  - Trichloroethylene
- Outdoor Industrial Worker: MLE
  - Trichloroethylene
- Construction/Utility Worker: RME
  - 1,2–Dichloroethane
  - Total PCBs
  - Trichloroethylene
- Construction/Utility Worker: MLE
  - 1,2–Dichloroethane
  - Total PCBs
  - Trichloroethylene

Mississippi River

No COCs Identified

Base map from URS entitled "SAUGET AREA 2, RI/FS, SAUGET ILLINOIS", dated 3/27/03, drawn by "djd" and designed by "sjs".

FILENAME: 610501B.DWG

REVISIONS — NO.: DESCRIPTION: DATE: BY:

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CONSTITUENTS OF CONCERN (COCs)
HUMAN HEALTH RISK ASSESSMENT
SAUGET AREA 2 RI/FS
SAUGET, IL

PROJECT NUMBER: 06105–009
DATE: 7/03
SCALE: 1"=1100'

FIGURE NUMBER: **ES-1**

SHEET NUMBER: X

8.2 ECOLOGICAL RISK ASSESSMENT

The objective of the BERA is to evaluate the potential for adverse ecological effects to biological receptors living within the aquatic and terrestrial ecosystems located on or adjacent to the Sites, as a result of exposures to Site-related constituents. The BERA is a baseline evaluation of ecological risks that utilizes both historical data regarding the Sites and data that were collected as part of investigative activities within the Mississippi River and the five Sites. The BERA was prepared using conservative, but realistic, assumptions about potential exposures and assumed that no remedial action has occurred.

This BERA was completed in accordance with a USEPA-approved Ecological Risk Assessment Work Plan, which was included as Section 12.0 to the SSP (URS, 2002). Data used in the completion of this BERA included laboratory analytical data that described the concentrations of constituent of potential ecological concern (COPECs) found within various abiotic and biotic matrices associated with the Sites and the Mississippi River.

Aquatic Ecological Risks in the Mississippi River

Potential ecological risks to aquatic receptors within the Mississippi River were assessed through the collection of surface water and sediment samples from locations upstream, adjacent to, and downstream of the five disposal Sites. The samples were chemically analyzed to determine the concentrations of COPECs possibly present. Bioassays were run on both surface water and sediment samples to evaluate acute and chronic toxic effects to the endpoint species. Additionally, bioaccumulation tests were conducted to determine the body burdens of COPECs in test organisms exposed to sediments for an extended period of time. Fish tissue body burdens identified in historic sampling activities was also evaluated to assess potential ecological impacts.

The SA2IGR is currently being implemented downgradient of SA2 Sites O, Q (North), R and S to control adverse impacts on the Mississippi River due to groundwater discharges from these Sites; Sauget Area 1 Sites G, H, I and L; and industrial facilities in Sauget and Cahokia, Illinois.

The results of the BERA for the different evaluated media are presented below.

Sediments – The BERA concluded that there were no adverse ecological impacts associated with the presence of COPECs in sediments.

Chemical analysis of sediments indicated that there were measurable concentrations of COPECs that exceeded conservative ecologically based benchmarks. The COPECs included VOCs such as acetone and chlorobenzene; SVOCs such as 1,2-dichlorobenzene; pesticides such as dieldrin, endrin aldehyde, heptachlor epoxide; herbicides such as MCPP; and metals such as arsenic, barium, cadmium, copper, lead, manganese, nickel, and zinc. The highest detected concentrations of organic COPECs were located along transects closest to the shore in the sampling area located downgradient of Site Q (North) and just downstream of Site R. None of the inorganic COPECs exceeded their respective benchmarks by a significant degree and the pattern of distribution throughout the sampling plots adjacent to or downstream of the SA2 Sites appeared to be random.

The sediment bioassays (considered to be a stronger indicator of potential toxic effects) demonstrated that there were no significant toxic effects in any of the Site-related sediment samples. For the acute toxicity test, there were no significant differences in mean survival when Site-related samples were compared to their respective control samples for any of the sampling sites adjacent to, or downstream of, the disposal areas. Similarly, the chronic test concluded that none of the sediment samples collected from any of the sampling plots exhibited mean growth that was significantly lower than the mean growth of the corresponding LCSs.

Surface Water - The BERA concluded that there were limited ecological impacts associated with the presence of COPECs in surface water.

Surface water COPECs identified through chemical analyses included p-chloroaniline, 2,4-D, aluminum (total), barium (dissolved, total), copper (total), iron (total), manganese (total), and vanadium (dissolved, total). P-chloroaniline had the greatest exceedance of its conservative screening benchmark, followed closely by 2,4-D. Maximum concentrations of these two constituents were detected at the sampling area downgradient of Site Q (North) and just downstream of Site R on the transects closest to the riverbank. Barium had the greatest exceedance of its benchmark, while the remaining metals only slightly exceeded their respective benchmarks.

Surface water bioassays indicated that acute toxicity was limited to the sampling area downgradient of Site Q (North) and just downstream of Site R. The sample with the lowest survival and young production corresponded to the surface water sample that had the highest

concentrations (by nearly an order of magnitude) of p-chloroaniline and 2,4-D. Chronic toxicity was also seen at other sampling locations downstream where detected concentrations of pchloroaniline and 2,4-D were noted.

Conclusion of the Aquatic Risk Assessment - The BERA concluded that no adverse ecological impacts were identified with sediments within the Mississippi River and only limited surface water impacts were identified. Two organic compounds (p-chloroaniline and 2,4-D) were identified as the principal COC in the surface water environment of the Mississippi River adjacent to the SA2 Sites.

Historical sampling performed at SA2 Site R, which is immediately upstream of Sampling Area R3, indicates that p-chloroaniline and 2,4-D are present at this site. Sediment and surface water sampling performed by Menzie-Cura in October and November 2000 indicated that groundwater discharging to surface water downgradient of Site R resulted in an adverse impact on the Mississippi River. Based on this information, USEPA issued a Unilateral Administrative Order (Docket No. V-W-'02-C-716) on September 30, 2002 for performance of an Interim Groundwater Remedy, consisting of installation of a physical barrier and groundwater extraction system downgradient of Site R, to protect the Mississippi River. Groundwater extraction started on July 15, 2003, and slurry trench excavation began on September 4, 2003 to be completed in the first quarter of 2004. The implementation of the SA2IGR will mitigate the discharge of contaminated groundwater into the river. This will eliminate the potential ecological risks identified with these two compounds. For that reason, no additional remedial action is considered necessary to protect the aquatic ecosystem in the Mississippi River.

Ecological Risks in the Floodplain

The BERA evaluated the potential for COPECs to impact Receptors of Interest (ROIs) with small home ranges (prairie vole and short-tailed shrew) and large home ranges (osprey, mink and red fox). Potential for adverse impacts was evaluated on a site-by-site basis for the vole and shrew because of their small foraging areas and on study area basis for the osprey, mink and fox because of their large foraging areas. For the small-ranging organisms at the individual sites, the prairie vole was considered the most appropriate indicator of potential ecological risks because habitat suitable to support the short-tailed shrew was not dominant at the five disposal areas (Sites O, P, Q, R and S). Risks to these organisms were calculated based on food chain models

using concentrations of COPECs identified in surface soil, plant tissues, and invertebrate body burdens as input parameters.

Potential floodplain ecological risks are summarized below.

Piscivores - A limited number of COPECs were identified for consumption of fish and surface water by the mink and osprey, two organisms that were evaluated based on aquatic exposures. From a habitat standpoint, the riverbank adjacent to the SA2 Sites is not good habitat for any fish-eating mammal. Much of the 14,000 linear feet of riverbank is covered with stone riprap, removing cover requirements that this animal has. The remainder of the bank contains piers, pilings, buildings and other human disturbances, which would further preclude fish-eating mammals from inhabiting the area.

Nitrobenzene, MCPP, PCBs, dioxins/furans, aluminum and antimony were all identified as COPECs for the mink. However, most of the estimated ecological risks for the mink were based on consumption of fish from the large pond. The large pond is one of two ponds located in the southern end of Site Q. Identified as Site Q (Ponds), these ponds are ephemeral water bodies that will support a fish community on a temporary basis only if fish are washed into the ponds through overbank flooding of the Mississippi River. Fish were collected from the large pond, prior to it's drying up, and analyzed for the presence of COPECs. If those fish are removed from the modeling, as the community no longer exists, then the only COPECs identified for the mink are MCPP and antimony. The adverse risks noted with those constituents were slight.

For the osprey, mercury was the only COPEC. The potential for an ecological risk was small. Since surface water concentrations and bioaccumulation factors were used to calculate fish tissue mercury concentrations, actual risks due to mercury are likely to be lower than the predicted risks.

Plants - The potential for direct impact to plants was evaluated by comparing surface soil concentrations to screening plant benchmarks. A variety of COPECs in each disposal site were identified with concentrations in excess of these benchmarks. Site S had the highest number of organic COPECs that exceeded the plant benchmarks, while Site Q had the highest number of inorganic COPECs in excess of the conservative screening plant benchmarks.

These benchmarks are considered to be highly conservative even by the authors of the benchmarks. While a number of COPECs were identified, no indication of impacts to plants was noted in field observations conducted at the Sites. The vegetative communities in each of the disposal areas were marked by robust and vigorous plant growth with no indications of phytotoxic effects. The prairie vole food chain model provides a more accurate assessment of potential plant impacts by evaluating the presence of COPECs that were identified in plant tissues as they relate to a higher trophic level receptor.

Herbivores - In examining the potential for ecological risks at the five disposal sites, only limited risks were identified at Site P or Site Q (South) for the prairie vole. Potential ecological risks were predicted at Site O (PCBs, dioxins/furans, mercury, and thallium) and Site S (pentachlorophenol, PCBs, and mercury). At Site O, only PCBs and dioxins/furans exceeded both the NOAEL and the LOAEL benchmark values for the prairie vole. Potential areas of ecological risk at Site O are centered on sampling locations W-O-1 and W-O-3 and are shown on Figures ES-1 through ES-3. Adverse risks were also predicted for Site R (cobalt and mercury), however Site R is covered with a dirt cap. Further, the cap is regularly mowed and, consequently, is not considered a viable habitat for the vole. The potential adverse risks estimated at Site R were not considered to be significant.

Carnivores - An assessment of the potential for site-wide adverse ecological impacts to the red fox were conducted to determine whether cumulative affects from the five disposal Sites would be noted. The assessment was made based on modeled exposure to prey items (the shorttailed shrew and the prairie vole). In keeping with OSWER Directive 9285.7-28P, as an upper trophic level organism, the red fox was considered be the more critical receptor while the importance of the two small mammals was as prey items.

Aluminum had the highest exceedance of both its ecotoxicity benchmark values. PCBs and dioxin/furans, which were expected to be in prey tissue based on the model parameters, also exceeded their ecotoxicity benchmarks. Site O and Site S were the only sites where PCBs were modeled to be present at elevated concentrations (in excess of TRV benchmarks) in both the shrew and the vole and these two sites served as the greatest contributor of PCB and dioxin/furan risks to the red fox. Since the risks for PCBs were predicted based on the shrew and the vole as a prey base for the fox, areas potentially needing remedial action to protect these organisms from

PCBs and dioxins/furans would also potentially protect the red fox. These areas are shown on Figures 9-2 and 9-3.

It is noted that the red fox has a mean home range of 1,727 acres; it is highly unlikely that the disposal sites (total area less than 150 acres) would support a large population of red fox. Noting the discontinuity of the sites, it is more likely that a small number of fox utilize a portion of different disposal areas for foraging, moving between contaminated and non-contaminated areas. Additionally, the fence surrounding Site R would limit access of the fox to this disposal area.

Ponds - The BERA also evaluated potential ecological risks to aquatic receptors associated with the aforementioned ponds. While sediment and surface water screening against conservative benchmarks indicated the presence of some organic and inorganic COPECs, acute and chronic toxicity testing of both matrices did not indicate any adverse effects.

However, as the ponds were mostly dried by the time this BERA was implemented and only a partial data set could be collected to evaluate them. Surface water and sediment quality data were collected in June 2003. These data will be presented in an addendum to this BERA at a future date.

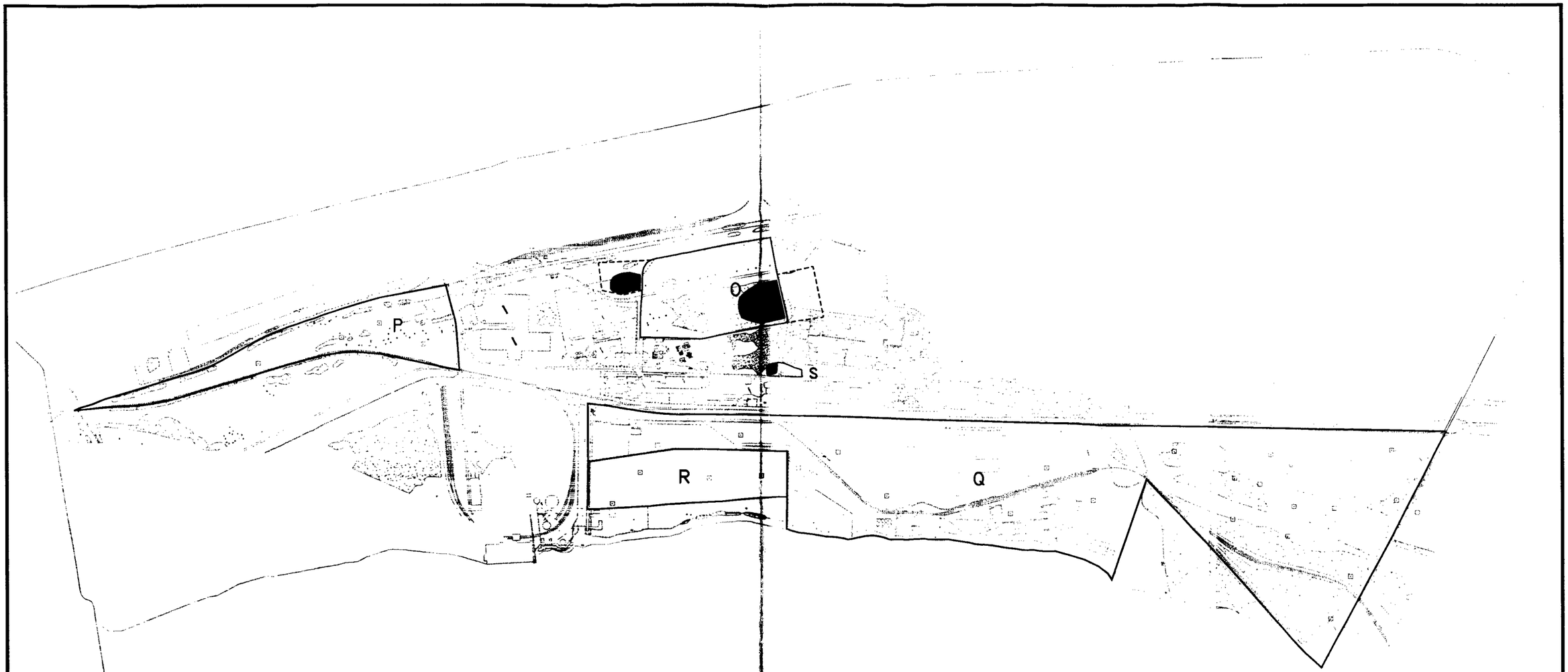
Conclusion of the Floodplain Risk Assessment - The BERA concluded that potentially significant ecological impacts were identified for Site O and for Site S. This determination was based on food chain modeling to the prairie vole and to the red fox.

Conclusions of the BERA

The BERA concluded that no adverse ecological impacts were associated with sediments within the Mississippi River. Limited surface water impacts based on toxicity testing were identified with p-chloroaniline and 2,4-D identified as the potentially principal COC in surface water. With the implementation of the SA2IGR at Site R, no additional remedial actions are considered necessary to protect the aquatic ecosystem in the Mississippi River.

The BERA also identified the potential for adverse ecological impacts associated with the presence of COPECs in surface soil found in Site O and Site S. For Site O, the most significant COPECs included dieldrin, lindane, PCBs, dioxins/furans, aluminum, and mercury. For Site S, the most significant COPECs included pentachlorophenol, beta-BHC, endrin, and lindane, and PCBs. These areas will be evaluated further in the Feasibility Study for the identification of

potential remedial actions. Limited ecological risks were identified with surface water and sediments in Site Q (Ponds), however, a further determination of potential ecological risk will be made upon the evaluation of surface water and sediment quality data collected in June 2003.



LEGEND

⊡ Waste Characterization Boring Location

Areas of Potential Ecological Concern

0 1000

SCALE FEET

SAUGET AREA 2
SAUGET ILLINOIS

Figure ES – 1

Areas of Potential Ecological Concern
Sauget Area 2 Sites

Date:	Project Number:	Scale:
3/18/03	1–7305–0000	AS SHOWN
Source: URS	**Checked by:**	**Sheet Number:**

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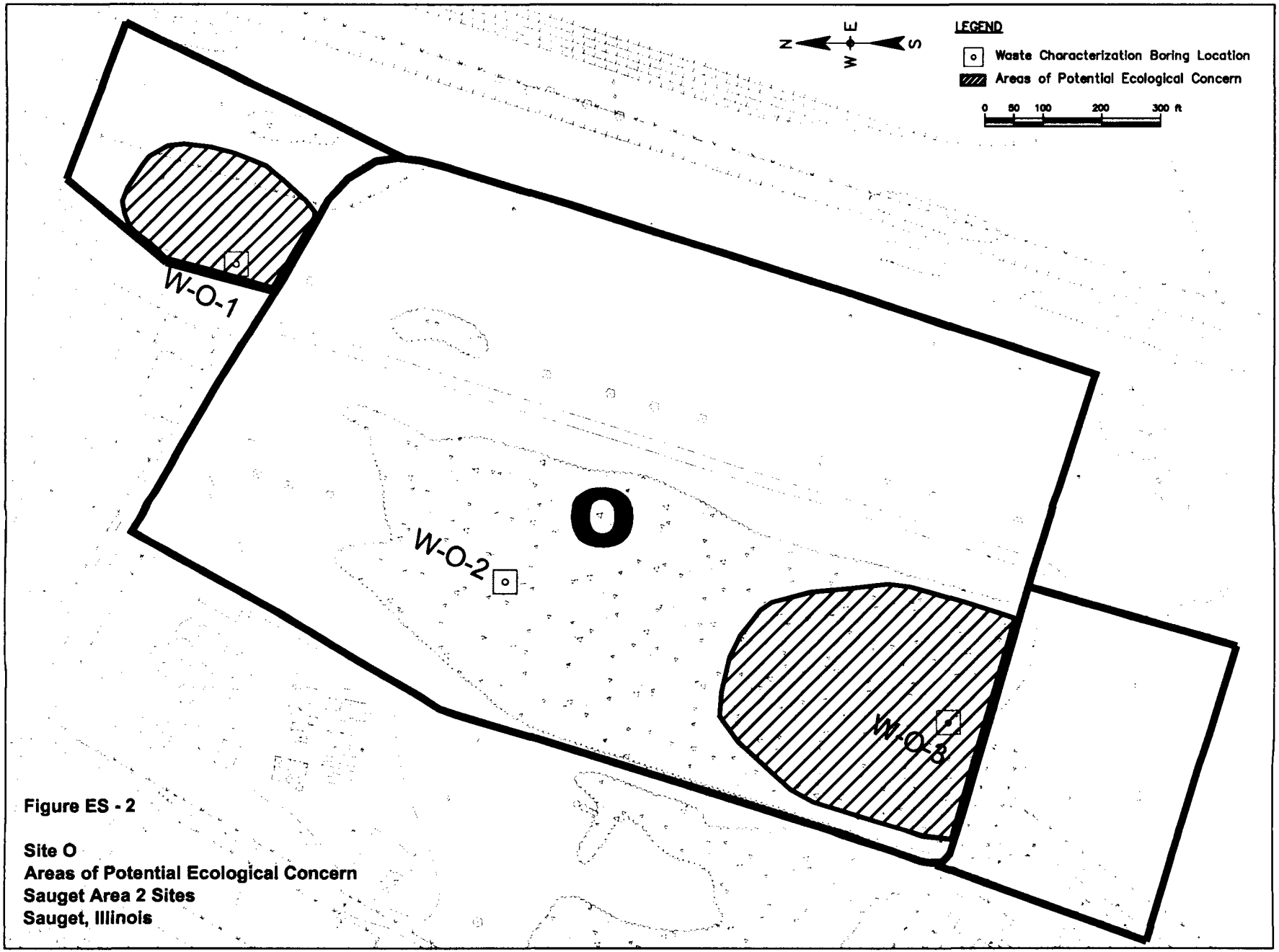

Figure ES - 2

Site O
Areas of Potential Ecological Concern
Sauget Area 2 Sites
Sauget, Illinois

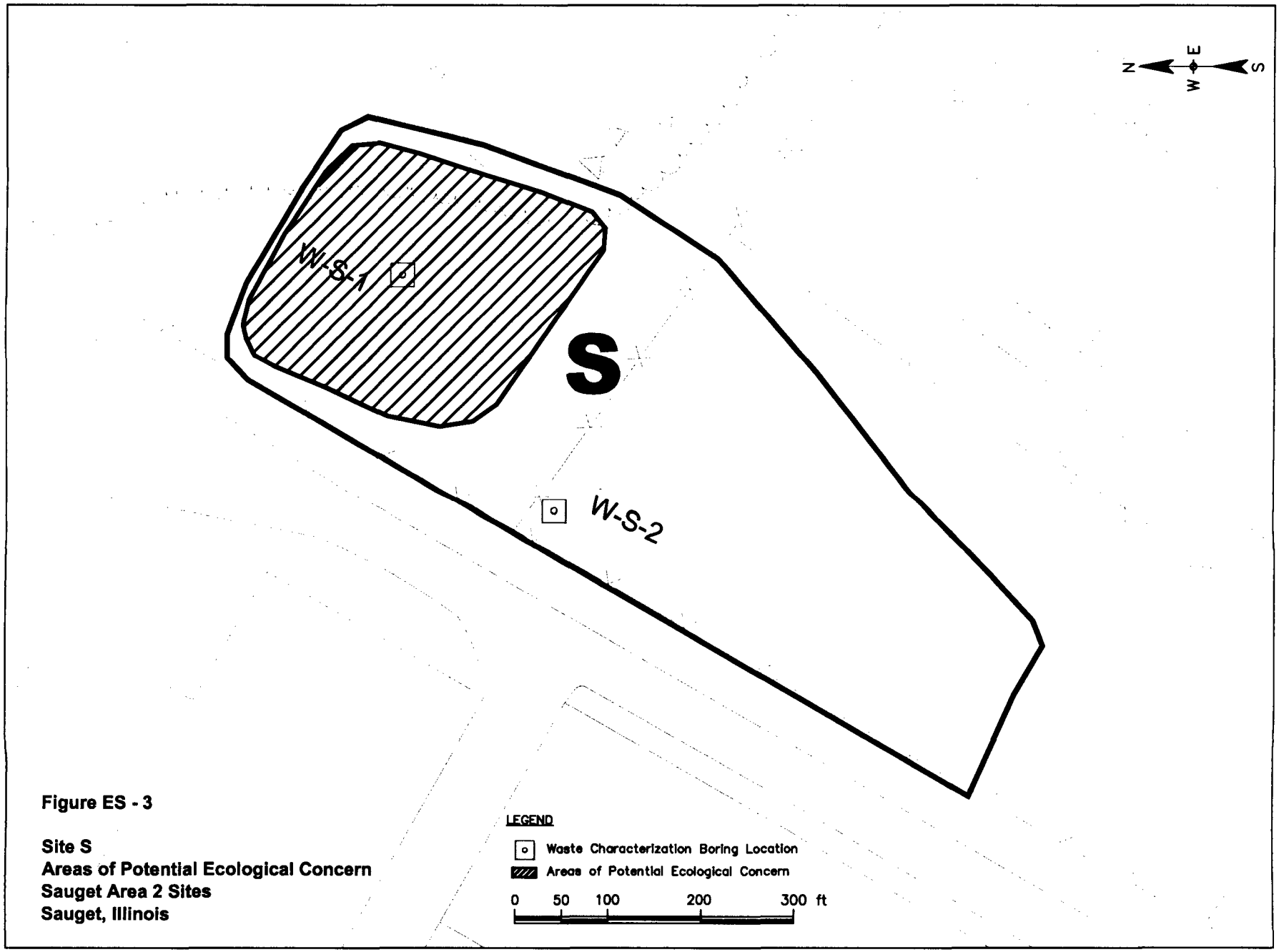

Figure ES - 3

Site S
Areas of Potential Ecological Concern
Sauget Area 2 Sites
Sauget, Illinois

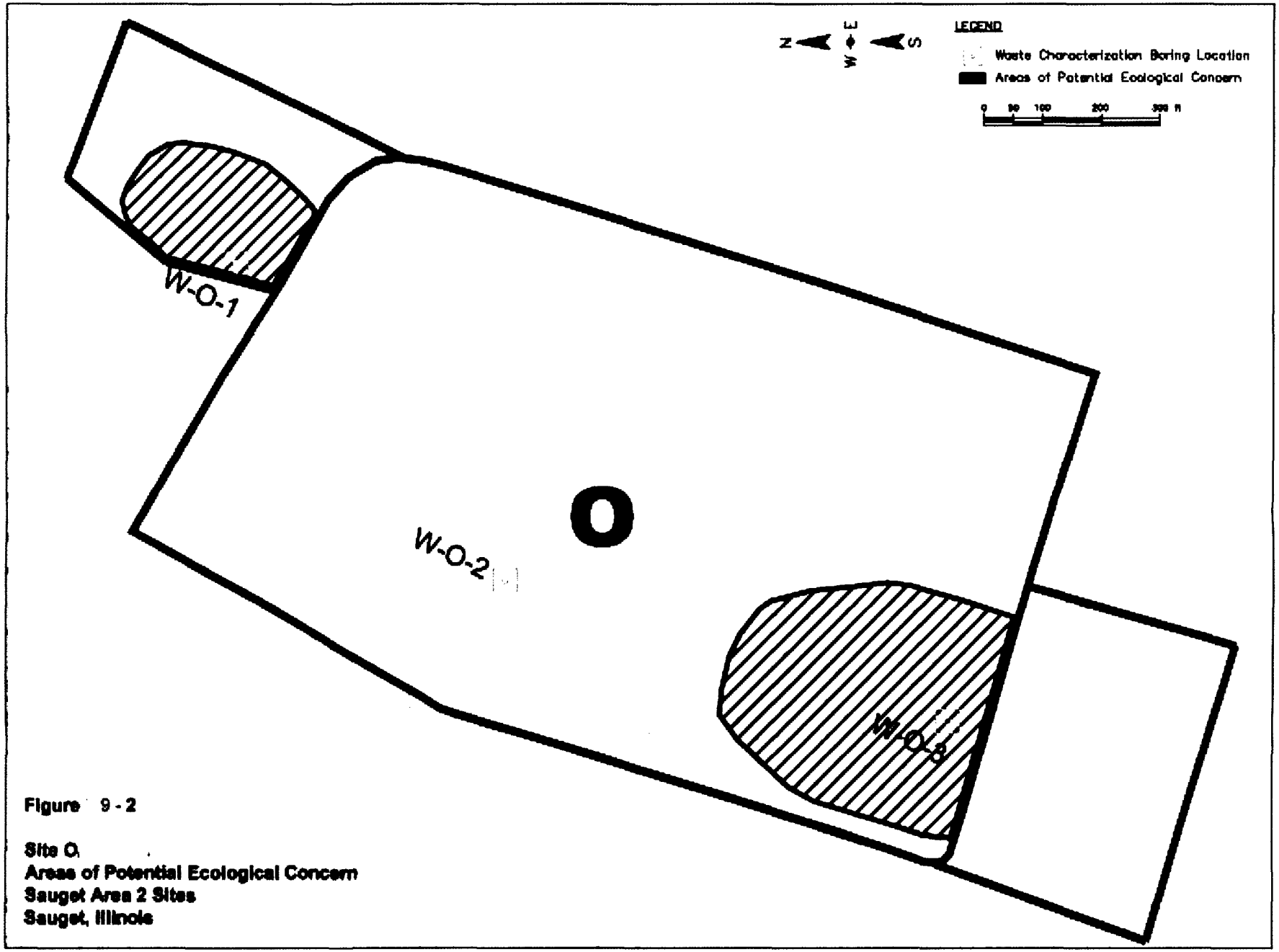

Figure 9 - 2

Site O
Areas of Potential Ecological Concern
Sauget Area 2 Sites
Sauget, Illinois

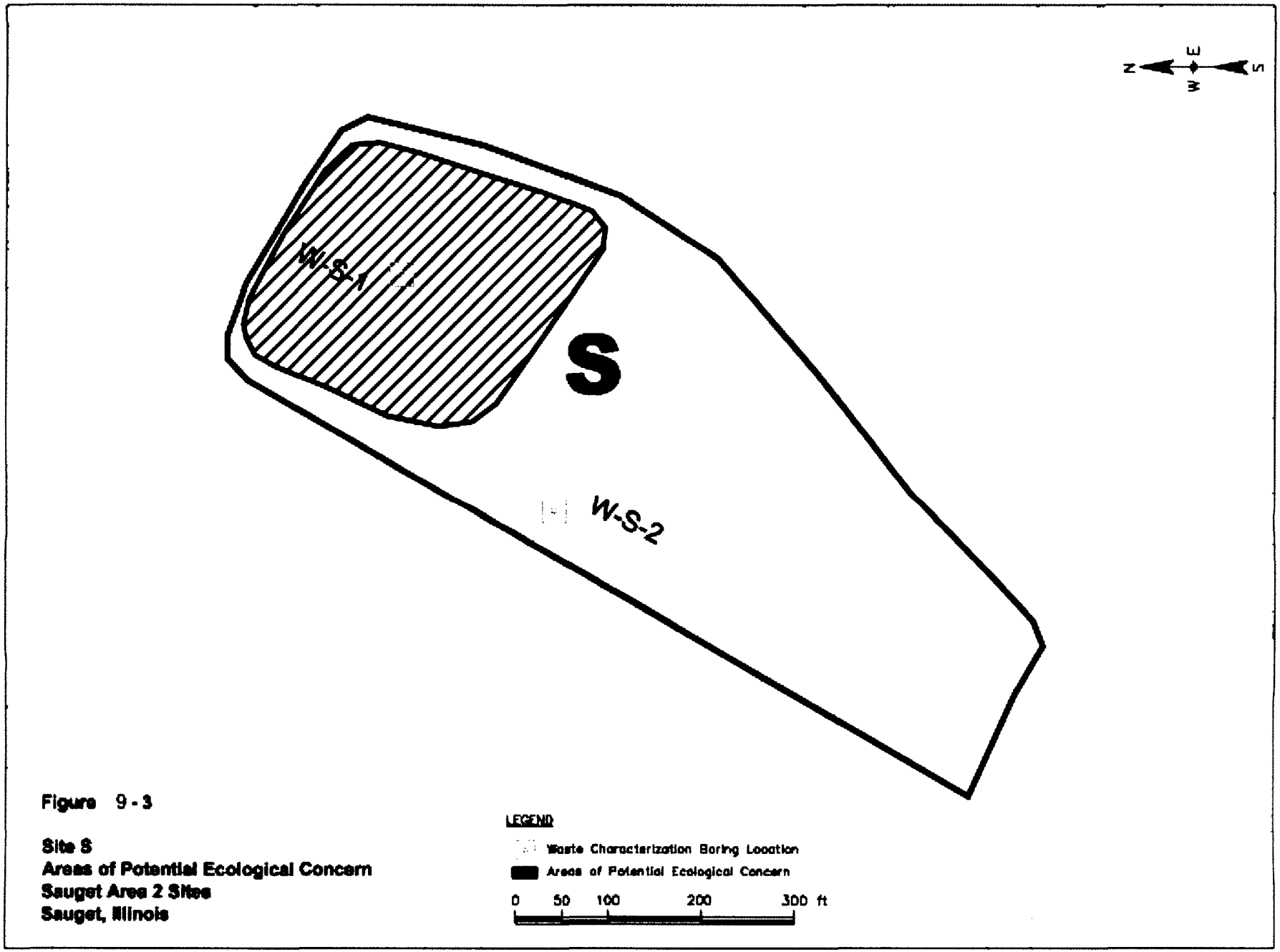

Figure 9 - 3

Site S
Areas of Potential Ecological Concern
Sauget Area 2 Sites
Sauget, Illinois

9.1 IDENTIFICATION OF REMEDIAL ACTION OBJECTIVES SAUGET AREA 2

Remedial action objectives (RAOs) form the basis for identifying remedial technologies and developing remedial alternatives for further evaluation. This section identifies the RAOs for the SA2 Sites (O, P, Q, R, and S) (Figure 3-2), as well as for the area wide groundwater and the Mississippi River. The information presented in this section forms the basis for developing and evaluating remedial alternatives.

RAOs are site-specific, qualitative objectives based on the nature and distribution of contamination, the resources currently or potentially threatened, and the potential for human and environmental exposure. RAOs for SA2 were formulated based on environmental concerns defined in the HHRA and the BERA. It should be noted that the use of groundwater in the vicinity of the SA2 Site as a drinking water source is prohibited. As a result, the HHRA evaluated potential incidental exposures to groundwater (i.e., non-drinking water scenarios) including contact by a construction/utility worker performing excavation in the area or volatilization through the soil column resulting in exposure to chemicals of concern in indoor or outdoor air.

The RAOs for each of the SA2 Sites, as well as groundwater and the Mississippi River are discussed in the following subsections.

9.1.1 Site O

The HHRA indicated that all potential carcinogenic risks calculated for both the reasonable maximum exposure (RME) and most likely exposure (MLE) receptor scenarios are within or below the USEPA's target carcinogenic risk range of 10^{-6} to 10^{-4}. However, there were non-carcinogenic risks above USEPA's target hazard index (HI) of 1 for two receptor scenarios. The RME for a future construction/utility worker was exceeded due to exposure to site soils containing chlorobenzene, xylenes, benzene, and total PCBs; and the RME for an outdoor industrial worker was exceeded due to exposure to site soils containing xylenes.

The BERA also identified the potential for adverse ecological impacts associated with dieldrin, lindane, PCBs, dioxins/furans, aluminum, and mercury in surface soils located at Site O.

Of the three waste samples, O-1 through O-3, collected at Site O, two of the samples (O-2 and O-3) contained chemical constituents that exceeded regulatory criteria (Table 6-3) indicating the waste material within the site can be considered characteristically hazardous.

As a result, the following site specific RAOs have been developed for Site O:

- Minimize potential risks to human receptors (future construction/utility workers, and outdoor industrial workers) resulting from exposure to unacceptable concentrations of chlorobenzene, xylenes, benzene, and total PCBs found in site soils at Site O.
- Minimize potential risks to ecological receptors resulting from exposure to unacceptable concentrations of dieldrin, lindane, PCBs, dioxins/furans, aluminum, and mercury found in surface soils at Site O.
- Minimize the potential for the infiltration of surface water to prevent the generation of leachate at Site O.

9.1.2 Site O North

The HHRA indicated exceedances of USEPA's target carcinogenic risk range of 10^{-6} to 10^{-4} and target HI of 1 for several Site O North receptor scenarios. Carcinogenic risks to an outdoor industrial worker were noted under the RME due to exposure to site soils containing total PCBs and dioxin TEQs; and under the MLE due to exposure to site soils containing dioxin TEQs. The outdoor industrial worker also experienced non-carcinogenic risk under the RME due to exposure to site soils containing xylenes and total PCBs and under the MLE due to exposure to total PCBs.

Carcinogenic risks to a construction/utility worker were noted under the RME due to exposure to site soils containing dioxin TEQs. The construction/utility worker experienced non-carcinogenic risk under the RME due to exposure to site soils and leachate containing xylenes and total PCBs, and under the MLE due to exposure to leachate containing total PCBs.

In addition, carcinogenic risks to a trespassing teenager were noted under the RME due to exposure to site soils containing dioxin TEQs. The trespassing teenager experienced non-carcinogenic risk under the RME and MLE due to exposure to site soils containing total PCBs.

No additional ecological risks were noted specifically related to Site O North. Waste sample O-1 was collected in the general vicinity of Site O North and did not exhibit chemical constituents above regulatory levels (Table 6-3).

As a result, the following site specific RAOs have been developed for Site O North:

- Minimize potential risks to human receptors (future construction/utility workers, outdoor industrial workers, and trespassing teenagers) resulting from exposure to unacceptable concentrations of xylenes, total PCBs, and dioxin TEQs found in site soils at Site O North.
- Minimize potential risks to human receptors (future construction/utility workers) resulting from exposure to unacceptable levels of total PCBs found in the leachate at Site O North.
- Minimize the potential for the infiltration of surface water to prevent the generation of leachate at Site O North.

9.1.3 Site P

The HHRA indicated that all potential risks, both carcinogenic and non-carcinogenic, calculated for both the RME and MLE receptor scenarios are within or below the USEPA's target risk range of 10^{-6} to 10^{-4} and below the HI of 1. In addition, no ecological risks were identified for Site P and waste samples P-1 through P-4 did not exceed regulatory criteria (Table 6-3). As a result, no site specific RAOs have been developed for Site P.

9.1.4 Site Q North

The HHRA indicated that all potential carcinogenic risks calculated for both the RME and MLE receptor scenarios are within or below the USEPA's target risk range of 10^{-6} to 10^{-4}. However, there were exceedances of the USEPA's target HI of 1 for two receptor scenarios evaluated. The RME and MLE for a future construction/utility worker was exceeded due to exposure to leachate containing 2,4,6-Trichlorophenol and 2,4-Dichlorophenol. No potential ecological effects were noted.

The concentration of 2,4,6-Trichlorophenol in waste sample Q-1 exceeded regulatory criteria (Table 9-1) indicating the waste material within the site can be considered characteristically hazardous.

As a result, the following site specific RAOs have been developed for Site Q North:

- Minimize potential risks to human receptors (future construction/utility workers) resulting from exposure to unacceptable concentrations of 2,4,6-Trichlorophenol and 2,4-Dichlorophenol found in the leachate at Site Q North.
- Minimize the potential for the infiltration of surface water to prevent the generation of leachate at Site Q North.

9.1.5 Site Q Central

The HHRA indicated that all potential risks, both carcinogenic and non-carcinogenic, calculated for both the RME and MLE receptor scenarios are within or below the USEPA's target risk range of 10^{-6} to 10^{-4} and below the hazard index (HI) of 1. In addition, no ecological risks were identified for Site Q Central and waste samples Q-6 through Q-8 did not exceed regulatory criteria (Table 6-3). As a result, no site specific RAOs have been developed for Site Q Central.

9.1.6 Site Q South

The HHRA indicated that all potential risks, both carcinogenic and non-carcinogenic, calculated for both the RME and MLE receptor scenarios are within or below the USEPA's target risk range of 10^{-6} to 10^{-4} and below the hazard index (HI) of 1. In addition, no ecological risks were identified for Site Q South and waste samples Q-9 through Q-12 did not exceed regulatory criteria (Table 6-3). As a result, no site specific RAOs have been developed for Site Q South.

9.1.7 Site Q Ponds

The HHRA indicated exceedances of USEPA's target risk range of 10^{-6} to 10^{-4} and target HI of 1, for the ingestion of fish scenario by a recreational fisherman at Site Q Ponds. Carcinogenic risks were noted from exposure to total PCBs, dieldrin, dioxin TEQs, benzo(a)pyrene, and arsenic, through the consumption of fish fillets. Non-carcinogenic risks were noted from exposure to total PCBs only, again through the consumption of fish fillets. It should be noted that while fishing could potentially occur in the Site Q Ponds, because of their ephemeral nature,

the RME which is based on 22 fish meals per year is unlikely. No carcinogenic risks were related to the MLE and total PCBs presented the only non-carcinogenic risk under the MLE scenario.

The BERA indicated that while sediment and surface water collected from the ponds contained some organic and inorganic COPECs, acute and chronic toxicity testing did not indicate any adverse effects.

No waste samples were collected from within the ponds but waste samples Q-9 through Q-12 were collected in the general vicinity of the ponds and did not exceed regulatory criteria (Table 6-3).

As a result, the following site specific RAOs have been developed for Site Q Ponds:

- Minimize potential risks to human receptors (recreational fisherman) resulting from exposure to unacceptable concentrations of total PCBs, dieldrin, dioxin TEQs, benzo(a)pyrene, and arsenic, through the consumption of fish fillets obtained from Site Q Ponds.

9.1.8 Site R

The HHRA indicated exceedances of USEPA's target risk range of 10^{-6} to 10^{-4} and target HI of 1 for several Site R receptor scenarios. Carcinogenic risks to an outdoor industrial worker were noted under the RME due to exposure to site soils containing trichloroethylene and under the RME and MLE due to exposure to leachate containing trichloroethylene.

Carcinogenic risks to a construction/utility worker were noted under the RME due to exposure to trichloroethylene (site soils and leachate), total PCBs (leachate), and 1,2-dichloroethane (leachate); and under the MLE due to exposure to leachate containing trichloroethylene.

The construction/utility worker experienced non-carcinogenic risk under the RME due to exposure to site soils containing trichloroethylene. The worker also experienced risk under the RME and MLE due to exposure to leachate containing trichloroethylene, total PCBs, and 1,2-dichloroethane.

No ecological risks were identified for Site R. However, all four waste samples collected from Site R, R-1 through R-4, exhibited chemical constituents that exceeded regulatory criteria

(Table 9-1) indicating the waste material within the site can be considered characteristically hazardous.

As a result, the following site specific RAOs have been developed for Site R:

- Minimize potential risks to human receptors (future construction/utility workers and outdoor industrial workers) resulting from exposure to unacceptable concentrations of trichloroethylene, total PCBs, and 1,2-dichloroethane, found in site soils at Site R.
- Minimize potential risks to human receptors (future construction/utility workers) resulting from exposure to unacceptable levels of trichloroethylene, total PCBs, and 1,2-dichloroethane found in the leachate at Site R.
- Minimize the potential for the infiltration of surface water to prevent the generation of leachate at Site R.

9.1.9 Site S

The HHRA indicated exceedances of USEPA's target risk range of 10^{-6} to 10^{-4} and target HI of 1 for several Site S receptor scenarios. Carcinogenic risks to an outdoor industrial worker were noted under the RME due to exposure to site soils containing total PCBs. The outdoor industrial worker also experienced non-carcinogenic risk under the RME and MLE due to exposure to total PCBs found in site soils. In addition, a construction/utility worker and trespasser also experienced risk under the RME due to exposure to total PCBs in site soils.

The BERA also identified the potential for adverse ecological impacts associated with pentachlorophenol, beta-BHC, endrin, lindane, and PCBs in surface soils located at Site S.

Three waste samples, S-1 through S-3, were collected at Site S and all contained chemical constituents that exceeded regulatory criteria (Table 6-3) indicating the waste material within the site can be considered characteristically hazardous.

As a result, the following site specific RAOs have been developed for Site S:

- Minimize potential risks to human receptors (future construction/utility workers, outdoor industrial workers, and trespassers) resulting from exposure to unacceptable concentrations of total PCBs found in site soils at Site S.

- Minimize potential risks to ecological receptors resulting from exposure to unacceptable concentrations of pentachlorophenol, beta-BHC, endrin, lindane, and PCBs found in surface soils at Site S.
- Minimize the potential for the infiltration of surface water to prevent the generation of leachate at Site S.

9.1.10 Mississippi River

The HHRA indicated that all potential risks, both carcinogenic and non-carcinogenic, calculated for both the RME and MLE receptor scenarios are within or below the USEPA's target risk range of 10^{-6} to 10^{-4} and below the HI of 1.

The BERA concluded that no adverse ecological impacts were identified for sediments within the Mississippi River but limited surface water impacts were identified. These were related to groundwater discharging to surface water downgradient of Site Q North and just downstream of Site R. These risks are currently being managed by the installation of a physical barrier and groundwater extraction. No additional unmanaged risks were identified.

As a result, the following RAOs have been developed for the Mississippi River in the vicinity of the SA2 Sites:

- Minimize the discharge of groundwater containing chemicals of concern, which result in an adverse ecological impact to the Mississippi River downgradient of Site R.

9.1.11 Summary of Remedial Action Objectives

Site specific and/or media specific RAOs were developed and are presented in the preceding sections. Aside from the individual chemicals of concern, the RAOs for the various sites at SA2 Sites are similar.

As a result, the RAOs for the SA2 as a whole can be summarized as follows:

- Minimize potential risks to human receptors resulting from exposure to the chemicals of concern found in site surface and subsurface soils at Site O, Site O North, Site R, and Site S.

- Minimize potential risks to human receptors resulting from exposure to the chemicals of concern through the consumption of fish fillets obtained from Site Q Ponds.
- Minimize potential risks to ecological receptors resulting from exposure to the chemicals of concern found in site surface soils at Site O and Site S.
- Minimize potential risks to human receptors resulting from exposure to the chemicals of concern found in leachate at Site O North, Site Q North, and Site R.
- Minimize the potential for the infiltration of surface water to prevent the generation of leachate and the associated risks at Site O North, Site Q North, and Site R.
- Minimize the potential for the discharge of groundwater containing chemicals of concern which result in an adverse ecological impact to the Mississippi River downgradient of Site R.

9.2 DETERMINATION OF REMEDIAL ACTION SCOPE

The scope of the remedial action activities for the SA2 Sites will be determined following approval of the RI/FS report and subsequent Proposed Plan and Record of Decision (ROD). The general scope will include source control and groundwater extraction and treatment, which will be accomplished through implementation of one of the alternatives described in the following sections. The selected alternative will meet the identified RAO's and comply with the ARARs.

9.3 DETERMINATION OF REMEDIAL ACTION SCHEDULE

The schedule for implementation of the remedial action will be developed following selection of an approved remedial alternative and signature of the ROD. In general, design of the selected remedial action can be completed in six to twelve months. The schedule for the remedial action activities will be determined following approval of the RI/FS report and subsequent Proposed Plan and ROD. It should be noted that sequencing of the construction at the various sites may be required which could extend the completion time.

9.4 IDENTIFICATION OF AND COMPLIANCE WITH ARARs

This section discusses the determination of ARARs for SA2. ARARs are categorized as chemical-specific, location-specific, or action-specific. The following paragraphs describe

ARARs for the fill areas. The ARAR discussion is limited to those of relevance to the SA2 Sites.

Chemical-specific ARARs define acceptable concentrations and are used to establish preliminary remediation goals. Chemical-specific ARARs include RCRA and Toxic Substances Control Act (TSCA) provisions for management of hazardous waste. 35 IAC 742 "sets forth procedures for evaluating the risk to human health posed by environmental conditions and developing remediation objectives that achieve acceptable risk levels." Although not specifically an ARAR, 35 IAC 742 may be considered in that it helps to ensure protectiveness and is otherwise appropriate for use in evaluating effectiveness of removal action alternatives. Relevance and applicability of chemical-specific ARARs are summarized in the following table.

Chemical-Specific ARARs			
Medium	**ARAR**	**Description**	**Applicability**
Fill Areas	40 CFR 261, 263 and 268	Classification, transport, and disposal of hazardous waste.	Relevant and Appropriate
	40 CFR 761	Defines requirements for management of PCB waste and PCB-contaminated materials under TSCA, including requirements for a chemical waste landfill.	Relevant and Appropriate
	40 CFR 766	Defines requirements for testing for dioxins under TSCA.	Relevant and Appropriate
	35 IAC 742	Provides for a tiered approach to developing remediation objectives, and describes how certain actions meet remediation objectives.	To be Considered
Groundwater	40 CFR 141.61	MCLs for organic chemicals for drinking water	Relevant and Appropriate
	40 CFR 141.62	MCLs for inorganic chemicals for drinking water	Relevant and Appropriate
	40 CFR 264.92	Establishes groundwater protection standards for hazardous waste treatment and disposal facilities	Relevant and Appropriate
	40 CFR 264.94	Establishes maximum concentration limits. Provides for establishment of alternate limits for groundwater protection	Relevant and Appropriate
	40 CFR 264.95	Establishes point of compliance for which groundwater quality standards apply	Relevant and Appropriate
	35 IAC 620	Defines classes of groundwater within the State of Illinois	Applicable
	35 IAC 620.410	Establishes numeric groundwater quality standards for Class I Potable Groundwater	Applicable

Location-specific ARARs set restrictions on activities within certain locations such as floodplains or wetlands. Brief descriptions of the relevance and appropriateness of location-specific ARARs are summarized in the following table.

Location-Specific ARARs			
Medium	**ARAR**	**Description**	**Applicability**
Fill Areas	40 CFR 6	Requires Federal agencies to evaluate the potential effects of actions to avoid adversely impacting floodplains, archeological sites, endangered species and wetland.	Applicable
	40 CFR 264.18	Establishes location standards for facilities where hazardous waste is disposed.	Relevant and Appropriate
	40 CFR 766	Defines requirements for testing for dioxins under TSCA.	Relevant and Appropriate
	35 IAC 742	Provides for a tiered approach to developing remediation objectives, and describes how certain actions meet remediation objectives.	To be Considered
Groundwater	40 CFR Part 6 and Appendix A	Requires Federal agencies to evaluate the potential effects of actions to avoid adversely impacting floodplains	Applicable

Action-specific ARARs set controls for particular treatment and disposal activities related to the management of hazardous waste. Brief descriptions of the relevance and appropriateness of action-specific ARARs are summarized in the following table.

Action-Specific ARARs			
Medium	**ARAR**	**Description**	**Applicability**
Fill Areas	40 CFR 264	Defines minimum standards for management of hazardous waste.	Relevant and Appropriate
	40 CFR 265	Defines requirements for construction maintenance closure and post-closure for hazardous waste landfills.	Relevant and Appropriate
	40 CFR 761	Requirements for management of PCB wastes and PCB-contaminated media.	Relevant and Appropriate
	29 CFR 1910.120	Standards for conducting work at hazardous waste sites.	Applicable
	35 IAC 724	Defines requirements for hazardous waste landfills including closure, post-closure and groundwater monitoring.	Relevant and Appropriate
	35 IAC 318 through 320	Describes standards for groundwater monitoring systems and programs, and groundwater quality standards for chemical waste landfills.	Relevant and Appropriate
	35 IAC 807.501	Describes general closure and post-closure care requirements for waste management sites.	Applicable
	35 IAC 811.111	Describes requirements for post-closure maintenance for all landfills.	Relevant and Appropriate
	35 IAC 142.305	Defines requirements for excluding exposure routes for contaminants of concern.	To be Considered
	35 IAC 811.111	Describes requirements for post-closure maintenance for all landfills.	Relevant and Appropriate

Action-Specific ARARs			
Medium	**ARAR**	**Description**	**Applicability**
Groundwater	40 CFR 125	Establishes technology-based limits for direct discharge of treatment system effluent	Applicable
	40 CFR 402	Controls direct discharge of pollutants to surface waters through the National Pollutant Discharge Elimination System (NPDES) program	Applicable
	40 CFR 403.5	Specifically prohibits the direct discharge of pollutants to a publicly-owned treatment works without treatment, that interfere with operations, or that contaminate sludge	Applicable
	29 CFR 1910.120	Standards for conducting work at hazardous waste sites	Applicable
	29 CFR 1926	OSHA safety and health standards	Applicable
	35 IAC 306.302	Standards for expansion of existing or establishment of new combined sewer service areas	Relevant and Appropriate
	35 IAC 307.1101	Sewer discharge criteria that prohibit entry of certain types of pollutants into a POTW	Applicable
	35 IAC 309.102	An NPDES permit is required for any discharge to the waters of the State of Illinois	Applicable
	35 IAC 309.202	A State construction permit is required for new sewer and wastewater sources	Applicable

9.5 IDENTIFICATION AND ANALYSIS OF REMEDIAL ACTION ALTERNATIVES

This section presents the development, screening and detailed evaluation of potential remedial action alternatives developed to address the SA2 Sites. These alternatives were developed based on site-specific conditions through consideration of presumptive remedies for landfills as described in Section 9.5.1. Separate alternatives were developed to address soil at each site as well as site-wide groundwater. Several of the SA2 Sites require no further evaluation since no risk to human health or the environment was identified. As a result, no remedial action alternatives are developed for them. These areas include the following:

- Site P
- Site Q Central
- Site Q South.

The sites for which remedial action alternatives will be evaluated include:

- Sites O and O North
- Site Q North
- Site Q (Ponds)

- Site R
- Site S.

Alternatives for soil at the SA2 Sites are developed to address the specific human health and ecological risks and the RAOs presented in Section 9.1.

9.5.1 Development of Alternatives for Soils

This section presents the development of alternatives to address impacted soil and other source material at the SA2 Sites. Source material is defined as material other than soil which may present a risk to human health or the environment. Presumptive remedies identified by USEPA for several types of sites and contaminants have been considered in this process. USEPA review of Superfund removal and remedial action programs since 1980 identified certain types of sites that can be grouped together based on similar characteristics, such as types of contaminants present, past use, and affected media (USEPA, 1993a). Based on that observation, USEPA identified presumptive remedies for certain types of sites and contaminants. Presumptive remedies are preferred technologies for common categories of sites based on historical experience. The objective of presumptive remedies is to use clean-up techniques shown to be effective in the past to expedite site investigations and the selection of remedial actions in the future.

USEPA identified five types of sites where use of presumptive remedies may be appropriate. These site types are as follows:

- Municipal landfill sites
- Military landfills
- Sites with VOCs in soils
- Sites with contaminated groundwater
- Wood-treater sites with soils, sediments, and sludges contaminated with certain organics and inorganics.

Of these, the guidance for municipal landfill sites (USEPA, 1993c), and military landfills, (USEPA, 1996) are considered applicable for the SA2 Sites and are relevant to the analysis present herein. The presumptive remedy guidance for CERCLA municipal landfill sites

indicates that, waste in CERCLA landfills usually is present in large volumes and is a heterogeneous mixture of municipal waste frequently co-disposed with industrial and/or hazardous waste. Because treatment usually is impracticable, USEPA generally considers containment to be the appropriate response action, or the "presumptive remedy," for the source areas of municipal landfill sites. USEPA has also evaluated application of the CERCLA municipal landfill presumptive remedy to military landfills (USEPA, 1996). This evaluation indicated that the following criteria must be considered when assessing whether a military landfill can be addressed utilizing the presumptive remedy for municipal landfills.

- Volume of landfill contents
- Type of wastes
- Hydrogeology
- Safety
- Practicality of excavation, consolidation and treatment of the waste.

Although the SA2 Sites are not military CERCLA landfills or municipal landfills, they possess similar characteristics and their size, volume, and mixture of waste types and contaminants makes it impractical to excavate most of them. USEPA has indicated that although no set excavation volume limit exists, landfills with contents of more than 100,000 cubic yards would not normally be considered for excavation (USEPA, 1996). Site O and O North (603,000 cubic yards), Site Q North (1,077,000 cubic yards), and Site R (883,000 cubic yards) all far exceed 100,000 cubic yards of contents.

Use of the presumptive remedy eliminates the need for the initial identification and screening of alternatives during the feasibility study (FS). Section 300.430(e)(1) of the NCP states that, "...the lead agency shall include an alternatives screening step, when needed, (emphasis added) to select a reasonable number of alternatives for detailed analysis." Although Sites O and O North, Q North, and R clearly meet the criteria for implementation of a conditional remedy, an alternative development and screening process was completed to further assess remedial action alternatives, and is presented below.

9.5.1.1 Screening of Potential Soil Alternatives

The process of developing remedial action alternatives for the SA2 Sites included analysis of a conditional remedy and screening of several potential alternatives. Additional alternatives were evaluated to identify those that may be implementable at the site. A list of potential alternatives was developed and then screened to identify alternatives for which a detailed and comparative analysis would be completed. Potential alternatives which undergo the initial screening process include the following:

- No Action
- Institutional Controls
- In-Situ Treatment
- Capping or Covering the Site
- Excavation and On-Site Disposal
- Excavation and Off-Site Disposal.

A preliminary screening step was completed to identify alternatives which will undergo the detailed analysis in Section 9.5.3. The screening was completed based on whether or not an alternative could meet the RAOs for the Site and was implementable. A discussion of this screening process is presented below.

No Action

This alternative will be included in the detailed analysis for comparative purposes consistent with CERCLA requirements.

Institutional Controls

Institutional controls would include access restrictions, deed restrictions, and monitoring. . They can be applicable as a stand-alone alternative or as part of an alternative For Site Q Ponds, institutional controls alone may address site risks and meet RAOs and will be evaluated as a standalone alternative. For the other sites, institutional controls will not be evaluated as a standalone alternative but may be considered as part of other alternatives.

In-Situ Treatment

In-situ treatment of contaminated material at the SA2 Sites could include stabilization, chemical oxidation, biological treatment, soil vapor extraction (SVE) or other.

For SA2 Sites O and O North, Q North, R, and S, several factors indicate that in-situ treatment is not likely implementable at the Site. These include the following:

- With sizes ranging from 24 to 53 acres the implementation of in-situ treatment at Sites O and O North, Q North, and R becomes impractical and difficult to implement and maintain.
- The mixture of waste types and contaminants including VOC, SVOCs, PCB, dioxins/furans, and heavy metals and the heterogeneity of the material at most of the sites would make in-situ treatment inefficient and difficult to implement, and removal of COCs to the extent necessary to meet RAOs for the site is very unlikely. Delivery of treatment reagents in a heterogonous mixture of waste materials and COCs is not likely feasible and would present significant risks to site workers due to potential chemical incompatibility risks. It is unlikely that in-situ treatment could remove enough contaminant mass to meet the RAOs or significantly reduce the time required to meet groundwater standards and the sites would have to be capped following in-situ treatment.

Based on this evaluation, in-situ treatment at the SA2 Sites will not be evaluated as a potential remedial action alternative.

Capping or Covering

The CERCLA presumptive remedy for large municipal and military landfills includes installation of an engineered cap. Although the SA2 Sites considered in the FS are not municipal landfills, they are sufficiently similar to landfills that a detailed evaluation of capping of all the sites except the Site Q Ponds will be included in Section 9.5.3.

Excavation and On-Site Disposal

Excavation, some treatment, and on-site disposal is also a potential remedial action alternative for soils at the SA2 Sites. Since the sites contain hazardous waste, the disposal cell or cells would have to comply with RCRA Subtitle C Requirements and the Toxic Substances Control

Act for PCBs. This alternative can be screened out here from further consideration due to implementability and other concerns. Construction of an on-site disposal cell for the contents of all the SA2 Sites would require a large landfill and construction of a cap. The process of excavating, moving and landfilling of an estimated 3.5 million cubic yards of material would present significant short-term risks at the site and in the area. This alternative would require on-site treatment prior to disposal of an estimated 875,000 cubic yards of soil which would take over five years to complete at an estimated daily production rate of 500 cubic yards per day. Sequencing of landfill construction, soil excavation and treatment, and placement in the landfill would be extremely difficult to implement. If smaller, individual on-site disposal cells were constructed at each site, the site would have to be excavated and the soil stockpiled or treated while the landfill was being constructed. Because of the nature of soils at these sites, long-term storage is not implementable at the SA2 Site.

Excavation and Off-Site Disposal

This alternative will be evaluated for Sites O and O North, Site R, Site Q North, and Site S. Excavation and off-site disposal of the soil and waste material is included to provide an evaluation of the feasibility of removing these materials from the SA2 Site. Based on the significant risks associated with excavation it appears that Site S is the only site where the risks associated with excavation would be manageable due to it's relatively small size. Evaluation of this alternative provides a detailed evaluation of removal of all the soil and waste material estimated to be at each site in Section 9.5.1.2.

SITE Q PONDS

The Site Q Ponds are significantly different from the other SA2 Sites. The only risk identified for this site is associated with potential consumption from fish that may be present seasonally in the ponds following a flood event. Alternatives to address these ponds, which will undergo detailed evaluation in Section 9.5.3.5 include the following:

- Alternative 1 – No Action
- Alternative 2 – Institutional Controls
- Alternative 3 – Constructed Wetlands

- Alternative 4 –Pond Liner
- Alternative 5 –Pond Filling.

9.5.1.2 General Description of Soil Alternatives

Three alternatives have been developed for SA2 Sites (O and O North, Q North, R, and S) which are very large and where excavation and in-situ treatment is impractical. For Site S and the Q Ponds area, site specific alternatives are developed in Section 9.5.3 since those sites do not meet the size or other criteria for a presumptive remedy. Presented below is a description of the three alternatives which are applicable for the large sites where a presumptive remedy is potentially appropriate. These alternatives include:

- No Action
- Capping or Covering
- Excavation, Treatment, and Off-site Disposal of Soil/Waste Material.

Presented below is a discussion of each of the SA2 Sites where remedial action is required to meet the RAOs. For each site, potential alternatives are described, undergo a detailed evaluation, a comparative evaluation, and a cost estimate is presented.

No Action

The No Action Alternative is included for comparative purposes with the active alternatives developed for the site. This alternative assumes that no further investigation, corrective action or monitoring will be completed at the SA2 Sites. The no action alternative serves as a baseline to evaluate the conditions at each site if no further actions to minimize risk to human health or the environment were taken.

Capping/Covering

This alternative would involve placing either a RCRA/TSCA compliant cap or cover over the individual sites to limit exposure to impacted soils and to minimize infiltration of surface water. A cover could include an engineered soil cover or soil and geotextile cover. For sites where hazardous waste is known to be present, a RCRA cap would be placed over the site. For sites where PCBs are present, TSCA requirements also apply. The areas addressed by this alternative do contain hazardous waste and PCBs so a RCRA/TSCA compliant cap (RCRA cap) is assumed

for each site. The cap can include an asphalt or soil cover depending on the expected future use of the site and topography. A general description of the proposed cap is presented below.

Description of Landfill Caps/Covers

Landfill caps generally are designed to accomplish the following objectives:

- Prevent direct contact with landfill contents
- Minimize infiltration and resulting contaminant leaching to groundwater
- Control surface water runoff and erosion
- Control landfill gas where potential gas generation is a concern.

Landfill caps are generally constructed with a variety of components, including earthen materials and geosynthetic products. Components generally include a barrier layer, a drainage layer, and protective cover. Barrier layers are used where low-permeability materials are desired to reduce the potential for rainfall infiltration. Barrier layers can be comprised of low permeability clays, flexible geomembrane liners, or geocomposite liners wherein a bentonite clay layer is adhered to a flexible geomembrane liner.

Drainage layers are used in conjunction with low permeability caps. High-permeability soils such as clean sand or geonets are typically used as drainage layers. They are designed to collect rainfall and direct it to the landfill cap perimeter. Where low-permeability caps are used, gas collection layers are also usually used. Gas collection layers are also typically constructed of clean sand or geonets, and are installed between the low permeability layer and the waste.

The protective cover is typically a layer of vegetated earthen material or an engineered product like asphalt. Protective covers are used to prevent inadvertent penetration of critical landfill cap components.

For purposes of cost estimating for this report, three potential cap/cell alternatives were used including:

1. Construction of a vegetated RCRA cap over the existing landfill cells
2. Construction of an asphalt covered RCRA cap over the existing landfill cells

3. Construction of a new cell including base liner, leachate collection system, and vegetated RCRA cap.

Descriptions of the design assumptions used to estimate costs for the alternatives are presented below:

1. Vegetated RCRA Cap (Sites O, R, & S)

   - The vegetated RCRA Cap will consist of 24 inches of fill suitable for a vegetative growth layer. The cap surface will be graded to allow adequate drainage.
   - A drainage layer of geonet with one side of non-woven geotextile will be used as a drainage layer underlying the soil cover.
   - A 40 mil HDPE geocomposite with 0.75 lb/ft^2 bentonite will be used as the barrier layer beneath the drainage layer.
   - A bedding layer will separate the barrier layer and the underlying gas collection layer.
   - The gas collection layer will consist of geonet with both sides covered by non-woven geotextile.
   - General fill will be used below the gas collection layer as needed to achieve the required contours to construct the cap.

2. Asphalt Covered RCRA Cap (Site Q North)

   - The asphalt covered RCRA Cap will be constructed similar to the vegetated cap with the exceptions that the 24 inches of suitable fill will be replaced by asphalt over a stabilized subbase including stone and other suitable fill. The asphalt will including a wearing course over an intermediate binder course. The cap surface will be constructed to allow adequate drainage.
   - The drainage layer, barrier layer, bedding layer, and gas collection layer are similar to the vegetated RCRA cap description above.

For the SA2 Sites O and O North, R and S, a conceptual cap design is shown in Figure 9-1. Site Q North would be capped utilizing an asphalt top layer to provide for continued commercial uses of the site. The conceptual cap design for an asphalt cap is shown in Figure 9-2.

The approximate size of each SA2 Site which would be capped is summarized below:

- Site O and O North: 32 acres
- Site Q North: 53 acres
- Site R: 24 acres
- Site S: 0.8 acres.

Excavation Treatment and Off-site Disposal of Soil/Waste Material

This alternative will be evaluated for each of the SA2 Sites except for Site Q Ponds. Excavation and on-site disposal is not evaluated since a capping alternative is already being evaluated which would close the fill areas in place and would not require excavation of millions of cubic yards of waste material. The only reason to excavate the fill areas would be if the material was to be removed from the site.

This alternative would involve excavation of the sites where hazardous waste has been identified, including Sites O and O North, Q North, R, and S (Figure 3-2) and disposing of the excavated material in an off-site hazardous disposal facility or facilities. Since PCBs are present in someSA2 Sites, disposal facilities must also be permitted to dispose of PCB containing materials. Estimates of the volume of hazardous soils and waste material which would require excavation and disposal are summarized below:

Summary Waste Volumes
Sauget Area 2

Site	Areal Extent (square feet)	Depth (feet)	Total In-Place Volume (Cubic Yards)	Total Loose Volume (Cubic Yards)
O & O North	1,357,475	12.0	603,321	814,483
Q North	2,271,708	12.8	1,076,957	1,453,892
R	1,045,960	22.8	883,254	1,192,393
S	35,684	8.5	11,234	15,166
Totals			**2,574,766**	**3,475,934**

The combined loose volume of waste material which would require disposal is estimated at just under 3.5 million cubic yards. Because of RCRA land ban considerations, the soil and/or waste material that contains contaminants above applicable land disposal treatment standards will

require treatment prior to land disposal. This alternative assumes on-site thermal desorption would be utilized to meet these standards for the soil requiring treatment. It is also likely that some of the material containing higher levels of contaminants will require off-site incineration. In addition, this alternative assumes that the excavated material that would be taken to a RCRA landfill would require some stabilization for moisture content.

For the purposes of evaluating this alternative the following assumptions were made:

- Fifty percent of the excavated soil would be placed directly into an off-site hazardous waste landfill without treatment. An additional 20% is added to this volume of soil for stabilization of liquids.
- Twenty-five percent of the soil going to the RCRA landfill would require on-site treatment (thermal desorption) prior to disposing in the off-site landfill.
- Twenty-five percent of the soil would require incineration because it would not be amenable to on-site treatment and subsequent disposal.

This alternative also assumes the excavated areas would be backfilled and restored to previous grade.

This alternative would also require significant efforts to minimize the release of VOCs to the environment during excavation. High levels of VOCs have been detected in waste characterization samples from each of the sites. Much of the work would require Level B PPE to protect excavation workers. In addition, extensive stormwater management and erosion control systems would be required at all the sites to minimize the potential runoff of contaminants during excavation.

9.5.2 Detailed Evaluation Criteria for Soil Alternatives

This section presents a description of the detailed evaluation of alternatives in the context of specific evaluation criteria developed to address CERCLA requirements and technical and policy considerations proven to be important for selecting remedial alternatives. The detailed evaluations of alternatives to address Sites O and O North, Site Q North, Site R, Site S, and Site Q Ponds are presented in Tables 9-1 to 9-18.

The remedial action alternatives developed for the Site will be evaluated according to the short-term and long-term aspects of the following criteria:

Primary Criteria

- Overall Protection of Public Health and the Environment
- Compliance with ARARs and other Criteria, Advisories, and Guidance

Balancing Criteria

- Long-Term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, or Volume Through Treatment
- Short-Term Effectiveness
- Implementability
- Cost.

Primary Criteria

Primary criteria focus on how risks posed through each exposure pathway are reduced, controlled, or eliminated through institutional controls, engineering controls, or treatment. There are two primary criteria: 1) overall protection of public health and the environment and 2) compliance with ARARs. According to the RI/FS guidance (EPA, 1988b), assessments against these criteria relate directly to statutory findings that must ultimately be made in the remedy selection. Therefore, these are categorized as threshold criteria that each alternative must meet.

The criterion of overall protection of public health and the environment assesses the adequacy of short-term and long-term protection from unacceptable risks associated with hazardous substances, pollutants, or contaminants at a site. Each risk and each pathway identified in the baseline risk assessment for a site must be addressed. An alternative that does not provide overall protection of public health and the environment cannot be considered for selection as the remedy for a site.

Assessing compliance with ARARs involves evaluating whether or not an alternative will meet all pertinent chemical-specific, location-specific, and action-specific ARARs. The regulations that are applicable or relevant and appropriate to an alternative will be described in the detailed analysis. In the event an ARAR cannot be complied with, discussion will be provided as to

whether or not a waiver can be justified. The ARARs must be met unless a specific ARAR is waived in accordance with the conditions and procedures identified in the NCP. In addition to complying with ARARs, compliance with TBC standards may be considered in the analysis.

Balancing Criteria

Balancing criteria are utilized to further evaluate the alternatives that satisfy the two threshold criteria. These balancing criteria include:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume
- Short-term effectiveness
- Implementability
- Cost.

The criterion of long-term effectiveness and permanence involves the assessment of the ability of a remedial alternative to maintain protection of human health over time. The level of risk associated with residual contaminants left on the Site and the effectiveness of the reliability of controls used to manage untreated wastes are also considered and evaluated. A preference for permanent solutions and alternative treatment technologies that do more than divert the risk is expressed in SARA.

The stated goal of SARA not only includes a preference for permanent solutions and alternative treatment, including innovative technology, but also for reduction of toxicity, mobility, or volume. The detailed analysis will consider how treatment reduces the toxicity, mobility, or volume of the waste and, if possible, to what extent. The degree to which the alternative is irreversible is a consideration in the evaluation of the reduction of toxicity, mobility, and volume.

Short-term effectiveness addresses the impact to the community and workers during the implementation of the remedy and until RAOs are met. Protecting human health and the environment during the remedy's implementation is the key goal of the short-term effectiveness criterion. Any risk resulting from the implementation of the remedial action will be assessed to establish short-term effectiveness.

Implementability refers to the technical and administrative feasibility of executing an alternative. Technical feasibility encompasses construction and operation considerations and the reliability of the technology. Other considerations relative to the technical implementability of an alternative include the reliability of the technology, the ease of undertaking additional remedial actions should they become necessary, the ability to monitor the effectiveness of the remedy and the availability of prospective technologies not yet demonstrated. Included in the evaluation of technical implementability will be a determination of the availability of resources necessary to implement the alternative as well as the assessment of the capabilities of various vendors.

The ability to coordinate implementation of an alternative with other involved agencies is the primary consideration in the assessment of administrative feasibility.

Estimates of the cost of implementing an alternative will include direct capital costs, indirect capital costs, and annual O&M costs. Direct capital items include equipment, land and site development, and buildings and utilities. Indirect capital costs include construction, engineering expenses, license or permit fees, start-up and shakedown costs, and contingency allowances. Operating labor, maintenance labor, energy, disposal of residues, purchased services such as sampling, administrative costs, insurance, taxes, maintenance reserve and contingency funds, rehabilitation or replacement, and 5-year reviews are typical elements of O&M cost estimates. As a final step, the present worth of all associated costs will be calculated so that the alternatives can be compared in today's dollars. The RI/FS guidance recommends a 30-year time frame for the development of present worth costs.

9.5.3 Description and Detailed Analysis of Soil Alternatives

The detailed evaluation of alternatives to address soil at each of the SA2 Sites is presented in Tables 9-1 through 9-18. This section presents the evaluation of remedial action alternatives on a site by site basis for the SA2 Sites. For each site, the following is presented:

- A discussion of the potential alternatives
- The detailed evaluation of potential alternatives versus the seven evaluation criteria
- A comparative analysis of the alternatives using a forced ranking system described below
- A cost estimate for each alternative including Capital Cost, Annual Operation and Maintenance Cost (if any), and a 30-year Present Worth Cost.

Each component of the alternatives is given a ranking of 1 through 3 for each criterion representing the best alternative to address the criteria (ranking of 1) to the least effective (ranking of 3). The scoring is based on engineering judgment based on review of the site conditions and professional judgment.

A summary of the total ranking for each component of each SA2 Site alternative is presented below. This scoring is utilized to complete a comparative analysis of the potential alternatives. The alternative with the lowest total score is considered the best alternative to address a particular site.

Presented below is the description, detailed evaluation, and comparative evaluation for remedial action alternatives for each of the SA2 Sites.

9.5.3.1 Site O and O North

Site O includes both Site O and O North for the purposes of this evaluation. The site is estimated to be 1.36 million square feet and 12 feet deep. This site covers an estimated 31 acres in area and an in-place waste/soil volume of 603,000 cubic yards. Sampling of waste materials in this area has identified characteristic hazardous wastes are present. Three potential alternatives were identified to address the RAOs for the site:

Alternative 1: No Action: As required by the NCP

The no action alternative would assume that no further investigation, monitoring, or remedial actions would be completed at the site.

Alternative 2: Install a Cap or Cover Over the Site

This alternative would include installation of a RCRA compliant cap over the 33 acre site since characteristic hazardous waste has been identified at the site. The general preliminary design of a RCRA cap was described in detail in Section 9.5.1.2. A conceptual site plan of a cap for the site is presented in Figure 9-1. A conceptual finished cap grading plan for the site is presented in Figure 9-3. Following construction of the cap, a fence will be installed around the site to restrict access. Gas venting will also be a part of the alternative which will allow management of landfill gas generated at the site. Long-term maintenance of the cap is also included in this alternative.

Alternative 3: Excavate, Treat, and Dispose of the Waste Material Off-Site

This alternative would include the excavation, treatment (as necessary), and off-site disposal of the waste material. A detailed description of this alternative was presented in Section 9.5.1.2. The following quantities of material requiring treatment and disposal are presented below:

Loose soil volume following excavation:	815,000 cubic yards
Volume assumed to be disposed at an off-site RCRA landfill including stabilization	692,000 cubic yards
Volume assumed to require on-site treatment utilizing thermal desorption and off-site disposal	204,000 cubic yards
Volume assumed to be treated at an off-site incinerator	204,000 cubic yards

The excavated area would be backfilled and restored to the original grade.

Summary of the Detailed Evaluation

Presented in Tables 9-1 through 9-3 is the detailed evaluation of each alternative for Site O and O North with regard to the seven evaluation criteria presented in Section 9.5.2. In addition, a comparative analysis is also presented which ranks each alternative against the others for each criterion with the low score representing the best alternative for achieving the RAOs.

Summary of the Comparative Analysis

A summary of the comparative analysis and total ranking for each component of the alternatives for Site O and O North is presented below:

Site O and O North	Alternative 1 No Action	Alternative 2 Install RCRA Cap	Alternative 3 Excavate, Treat and Dispose Off-Site
Overall Protection of Public Health and the Environment	2	1	3
Compliance with ARARs	3	2	1
Short-Term Effectiveness	2	1	3
Implementability	1	2	3
Long-Term Effectiveness and Permanence	3	2	1
Reduction of Toxicity	3	2	1
Cost	1 ($0)	2 ($7.8 MM)	3 ($562 MM)
Cumulative Score	15	**12**	15

The No Action alternative would not be protective of human health or the environment. Based on the large area and volume of material requiring excavation and off-site disposal at Site O, Alternative 3 is clearly not an implementable alternative. As described in the detailed evaluation, excavation of an estimated 815,000 cubic yards of impacted materials from this site would present very serious short-term risks to site workers and the community. Excavation of the site would likely result in significant releases of COCs into the environment no matter how carefully the removal was conducted. In addition, the number of trucks involved in removing excavated waste material and bringing in backfill would result in traffic, road condition, and air pollution problems. This project would be a massive excavation that would take at least 5 years to complete and would be extremely disruptive to the area surrounding the site. Erosion controls would also require a major effort to minimize release of impacted soils in stormwater from the site during excavation. With excavation of such a large volume of soil, a significant volume of contaminated stormwater runoff would likely be released from the site during the project regardless of the controls implemented. Finally, the actual capacity of hazardous waste disposal facilities off-site would not likely be able to accept the volume of material requiring disposal and it would severely impact hazardous waste disposal capacity in the region.

Based on the detailed evaluations presented in Tables 9-1 through 9-3, installing a RCRA cap over Site O and O North will protect human health and the environment and meet the RAOs developed in Section 9.1. Capping the site is implementable and could be completed within a reasonable time frame. The estimated 30-year present worth cost for this site is $7.8 million. This alternative is consistent with presumptive remedies for municipal landfills under CERCLA and does not present significant short-term impact to the surrounding environment.

9.5.3.2 Site Q North

Site Q North is approximately 52 acres in size and is shown in Figure 3-2. The site is also estimated to be 13 feet deep. The estimated volume of impacted soil/waste material is 1,077,000 cubic yards (in place). Sampling of materials in this site indicate the presence of characteristic hazardous waste. Three potential alternatives were identified to address the RAOs for the site:

Alternative 1: No Action: As Required by the NCP

The No Action alternative would assume that no further investigation, monitoring, or remedial actions would be completed at the site.

Alternative 2: Install a Cap or Cover

This alternative would include installation of a RCRA cap over the 52-acre site. For Site Q North, the cap design includes an asphalt cover to facilitate continued commercial operations at the site. The general preliminary design of a RCRA cap with an asphalt cover was described in detail in Section 9.5.1.2. A conceptual site plan of a cap for the site is presented in Figure 9-2. A conceptual finished cap grading plan for the site is presented in Figure 9-4. Following construction of the cap, a fence will be installed around the site to restrict access to the site. Gas venting will also be a part of the alternative which will allow management of landfill gas generated at the site. Long-term maintenance of the cap is also included in this alternative.

Alternative 3: Excavate, Treat, and Dispose of the Waste Material Off-Site

This alternative would include the excavation, treatment (as necessary), and off-site disposal of the material. A detailed description of this alternative was presented in Section 9.5.1.2. The following estimated quantities of material from Site Q North requiring treatment and disposal are presented below:

Loose soil volume following excavation:	1,460,000 cubic yards
Volume assumed to be disposed at an off-site RCRA landfill including stabilization	1,240,000 cubic yards
Volume assumed to require on-site treatment utilizing thermal desorption	364,000 cubic yards
Volume assumed to be disposed at an off-site incinerator	364,000 cubic yards

The excavated area would be backfilled and restored to the original grade.

Summary of the Detailed Evaluation

Presented in Tables 9-4 through 9-6 is a detailed evaluation of each alternative with regard to the seven evaluation criteria presented in Section 9.5.2. In addition, a comparative analysis is also presented in Tables 9-4 through 9-6, which ranks each alternative against the others and criteria with the low score representing the best alternative for achieving the RAOs. Presented below is a summary of the alternatives for soils at Site Q North.

Summary of the Comparative Analysis

A summary of the comparative analysis and total ranking for each component of the alternatives for Site Q North is presented below:

Site Q North	Alternative 1 No Action	Alternative 2 Install RCRA Cap	Alternative 3 Excavate, Treat and Dispose Off-Site
Overall Protection of Public Health and the Environment	2	1	3
Compliance with ARARs	3	2	1
Short-Term Effectiveness	2	1	3
Implementability	1	2	3
Long-Term Effectiveness and Permanence	3	2	1
Reduction of Toxicity	3	2	1
Cost	1 ($0)	2 ($12 MM)	3 ($1,000 MM)
Cumulative Score	15	**12**	15

The No Action alternative would not be protective of human health or the environment. Based on the large area and volume of material requiring excavation and disposal at the Q North site Alternative 3 is clearly not an implementable alternative. As described in the detailed evaluation, excavation of over 1,077,000 cubic yards of impacted materials from this site would present very serious short-term risks to site workers and the community. Excavation of the site would likely result in significant releases of COCs into the environment no matter how carefully the removal was conducted. In addition, the number of trucks involved in removing excavated waste material and bringing in backfill would result in traffic, road condition, and air pollution problems. This project would be a massive excavation that would take at least six years to complete and would be extremely disruptive to the area surrounding the site. This site is on the river side of the flood control levee, which would make excavation more difficult. Erosion controls would also require a major effort to minimize release of impacted soils in stormwater

from the site during excavation. With excavation of such a large volume of soil, a significant volume of contaminated stormwater runoff would likely be released from the site during the project regardless of the controls implemented. Finally, the actual capacity of hazardous waste disposal facilities off-site would not likely be able to accept the volume of material requiring disposal and it would severely impact hazardous waste disposal capacity in the region.

Based on the detailed evaluations presented in Tables 9-4 through 9-6, installing a RCRA cap over Site Q North will protect human health and the environment and meet the RAOs developed in Section 9.1. Capping the site is implementable and could be completed within a reasonable time frame. The estimated 30-year present worth cost for this site is $12 million. This alternative is consistent with presumptive remedies for municipal landfills under CERCLA and does not present a significant short-term impact for the surrounding environment.

9.5.3.3 Site R

Site R is estimated at 24 acres in size and is shown on Figure 3-2. The site contains approximately 883,000 cubic yards (in place) and waste is present to a depth of approximately 23 feet. Sampling of materials at Site R indicate the presence of characteristically hazardous waste. The following alternatives to address the RAOs will be evaluated for Site R.

Alternative 1: No Action: As required by the NCP

The No Action alternative would assume that no further investigation, monitoring, or remedial actions would be completed at the site.

Alternative 2: Install a RCRA Cap Over the Site

This alternative would include installation of a RCRA compliant cap over the 24-acre site. The general preliminary design of a RCRA cap was described in detail in Section 9.5.1.2. A conceptual site plan of a cap for the site is presented in Figure 9-1. A conceptual finished cap grading plan for the site is presented in Figure 9-4. Following construction of the cap, a fence will be installed around the site to restrict access to the site. Gas venting will also be a part of the alternative which will allow management of landfill gas generated at the site. Long-term maintenance of the cap is also included in this alternative.

Alternative 3: Excavate, Treat, and Dispose of the Waste Material Off-Site

This alternative would include the excavation, treatment (as necessary), and off-site disposal of the waste material. A detailed description of this alternative was presented in Section 9.5.1.2. Site R is located on the river side of the flood levee and is very close to the Mississippi River. The following quantities of material requiring treatment and disposal are presented below:

Loose soil volume following excavation:	1,200,000 cubic yards
Volume assumed to be disposed at an off-site RCRA landfill including stabilization	1,010,000 cubic yards
Volume assumed to require on-site treatment utilizing thermal desorption	298,000 cubic yards
Volume assumed to be disposed at an off-site incinerator	298,000 cubic yards

The excavated area would be backfilled and restored to the original grade.

Summary of the Detailed Evaluation of Alternatives for Site R

Presented in Tables 9-7 through 9-9 is a detailed evaluation of each alternative with regard to the seven evaluation criteria presented in Section 9.5.2. In addition, a comparative analysis is also presented in Tables 9-7 through 9-9 which ranks each alternative against the others for each criteria with the low score representing the best alternative for achieving the RAOs. Presented below is a summary of the comparative analysis and total ranking of the three alternatives for soils at Site R.

Summary of the Comparative Analysis

Site R	Alternative 1 No Action	Alternative 2 Install RCRA Cap	Alternative 3 Excavate, Treat and Dispose Off-Site
Overall Protection of Public Health and the Environment	2	1	3
Compliance with ARARs	3	2	1
Short-Term Effectiveness	2	1	3
Implementability	1	2	3
Long-Term Effectiveness and Permanence	3	2	1
Reduction of Toxicity	3	2	1
Cost	1 ($0)	2 ($6.7 MM)	3 ($823 MM)
Cumulative Score	15	**12**	15

The No Action alternative is not protective of human health or the environment. Based on the large area and volume of material requiring excavation and disposal and the proximity to the Mississippi River, Alternative 3 is clearly not an implementable alternative. As described in the detailed evaluation, excavation of over 1,077,000 cubic yards of impacted materials from this site would present very serious short-term risks to site workers and the community. Excavation of the site would likely result in significant releases of COCs into the environment no matter how carefully the removal was conducted. In addition, the number of trucks involved in removing excavated soil and bringing in backfill would result in traffic, road condition, and air pollution problems. This project would be a massive excavation that would take over 6 years to complete and would be extremely disruptive to the area surrounding the site. Erosion controls would also require a major effort to minimize release of impacted soils in stormwater from the site during excavation. This presents an increased risk at Site R due to its proximity to the river. With excavation of such a large volume of soil, a significant volume of contaminated stormwater runoff would likely be released from the site during the project. Finally, the actual capacity of hazardous waste disposal facilities off-site would not likely be able to accept the volume of

material requiring disposal and it would severely impact hazardous waste disposal capacity in the region.

Based on the detailed evaluation presented in Tables 9-7 through 9-9, installing a RCRA cap over Site R will protect human health and the environment and meet the RAOs developed in Section 9.1. Capping the site is implementable and could be completed within a reasonable time frame. The estimated 30-year present worth cost for this site is $6.7 million. This alternative is consistent with presumptive remedies for municipal landfills under CERCLA and does not present significant short-term impact to the surrounding environment.

9.5.3.4 Site S

Site S is estimated at 0.8 acres and is shown on Figure 3-2. The site is estimated to be 36,000 square feet and approximately 8.5 feet deep. The estimated volume of impacted soil/waste material is approximately 11,200 cubic yards (in place). Sampling of materials at Site S indicate the presence of characteristically hazardous waste. The following alternatives will be evaluated for Site S.

Alternative 1: No Action: As required by the NCP

The No Action alternative would assume that no further investigation, monitoring, or remedial actions would be completed at the site.

Alternative 2: Install a Cap of Cover Over the Site

This alternative would include installation of a RCRA compliant cap over the 0.8-acre site. The general preliminary design of a RCRA cap was described in detail in Section 9.5.1.2. A conceptual site plan of a cap for the site is presented in Figure 9-1. A conceptual finished cap grading plan for the site is presented in Figure 9-3. Following construction of the cap, a fence will be installed around the site to restrict access. Gas venting will also be a part of the alternative, which will allow management of landfill gas generated at the site. This alternative would also include fencing of the Site and long-term maintenance of the cap. Annual inspections of the cap are assumed and included in the cost estimate for this alternative.

Alternative 3: Excavate, Treat, and Dispose of the Waste Material Off-Site

This alternative would include the excavation, treatment (as necessary), and off-site disposal of the waste material. This general alternative was described in detail in Section 9.5.1.2. The following quantities of material requiring treatment and disposal at Site S are presented below:

Loose soil volume following excavation:	15,200 cubic yards
Volume assumed to be disposed at an off-site RCRA landfill including stabilization	12,900 cubic yards
Volume assumed to require on-site treatment utilizing thermal desorption	3,800 cubic yards
Volume assumed to be disposed at an off-site incinerator	3,800 cubic yards

Alternative 4: Excavate, Treat to the Extent Necessary, Dispose in an On-Site RCRA Cell

Because the size of Site S is less than one acre and the estimated waste volume is approximately 15,000 cubic yards, this alternative is potentially applicable at Site S. Implementation of this alternative would include the following:

- Excavation of the site (approximately 36,000 square feet, and 8.5 feet deep)
- Treatment of material where required by RCRA Land Ban requirements using thermal desorption
- Off-site incineration of material not amenable to on-site treatment
- Construction of an on-site hazardous waste landfill following applicable requirements including leachate collection
- Collected leachate would require disposal. Incineration is assumed for purposes of this alternative
- Placing soil into the landfill and installing a cap
- Long-term operation and maintenance of the landfill and cap.

A detailed description of the on-site landfill is presented below:

This alternative assumes the following quantities of material will be treated and disposed under this alternative.

Loose Volume of Material Following Excavation:	15,200 cubic yards
Material Volume Requiring On-Site Treatment Prior To On-Site Landfilling	3,800 cubic yards
Material Volume Requiring Off-Site Incineration:	3,800 cubic yards
Material Volume Placed On-Site Disposal Cell:	11,400 cubic yards

A conceptual design for the disposal cell is shown in Figure 9-2 and would include the following:

New Cell and RCRA Cap (Site S)

Construction of a new cell has been estimated with the assumptions that the base of the new cell will be a multi-layered system with two leachate collection zones. The uppermost layer will be a leachate collection unit consisting of geonet with both sides covered by non-woven geotextile.

Underlying the geonet/geotextile layer will be 8 inches of clean sand as the secondary leachate collection layer.

The bottom of the new cell will consist of a 40 mil HDPE geocomposite with 0.75 lb/ft^2 bentonite over a 3-foot thick layer of low-permeability clay.

The leachate collection layers must maintain a minimum of 1% slope and drain to sumps that can be pumped as part of regular O&M, per local regulations.

Cap construction design will be similar to the vegetated RCRA cap as outlined above.

NOTE: Cost estimate does not include potential expenditures for waste storage during the construction of the new cell. Location of the new cell and scheduling of the construction and waste relocation had not been determined at the time the cost estimate was created.

Leachate Collection and Treatment

Leachate collection and treatment involves processes to recover leachate generated by the landfill. Current practice for landfill design includes leachate collection systems, which typically are comprised of perforated collection pipes that collect and route leachate to sumps where it is removed by pumping. Leachate is then treated and discharged or disposed of in accordance with local regulations.

In the absence of built-in leachate recovery systems, leachate recovery wells can be installed to recover leachate from the base of the waste zone. Considering the heterogeneous nature of landfills, the effective radius of a recovery well is expected to be generally small and variable.

Landfill Gas Collection and Treatment

Landfill gas collection and treatment systems typically involve perforated pipes and other permeable media beneath a low permeability cover. The fill areas have been inactive for many years. The nature of the waste deposited in the fill areas is not expected to produce significant quantities of landfill gas; therefore, landfill gas collection and treatment is not considered a necessary process option for containment of the fill areas. However, provisions for venting to mitigate potential accumulation of gas is considered appropriate. For purposes of cost estimating, we have assumed that gas venting will consist of 6-inch diameter HDPE pipe with non-woven geotextile wrapped screen sections. The pipes will be equipped with carbon canisters to control potential landfill gas emissions. Landfill gas monitoring will be incorporated into the post-closure care program which is part of the institutional controls for containment to verify the performance of the gas venting system.

Summary of the Detailed Evaluation

Presented in Tables 9-10 through 9-13 is the detailed evaluation of each alternative with regard to the seven criteria described in Section 9.5.2. In addition, a comparative analysis is also presented in Tables 9-10 through 9-13 which ranks each alternative against the others for each criteria with the low score representing the best alternative for achieving the RAOs. Presented below is a summary of the comparative analysis of the four alternatives for soils at Site S.

Summary of the Comparative Analysis

A summary of the comparative analysis and total ranking for each criteria for the alternatives is presented below:

Site S	Alternative 1 No Action	Alternative 2 Install RCRA Cap	Alternative 3 Excavate, Treat and Dispose Off-Site	Alternative 4 Excavate, Treat and Dispose On-Site
Overall Protection of Public Health and the Environment	4	1	2	3
Compliance with ARARs	4	3	2	1
Short-Term Effectiveness	2	1	4	3
Implementability	1	2	3	4
Long-Term Effectiveness and Permanence	4	3	1	2
Reduction of Toxicity	4	3	1	2
Cost	1 ($0)	2 ($0.36MM)	3 ($10.5 MM)	4 ($11.4 MM)
Cumulative Score	20	**15**	16	19

The No Action alternative would not be protective of human health or the environment. Alternatives 2, 3, and 4 would be protective of human health and the environment and would meet the RAOs.

The table below summarizes the overall comparative analysis scoring for the soil/source areas of the Sites considered in this FS and the potential alternatives for each.

Site	O/O North	Q	R	S
Alternative				
No Action	15 ($0)	15 ($0)	15 ($0)	20 ($0)
Cap/Cover	12 ($7.8MM)	12 ($12MM)	12 ($6.7MM)	15 ($0.36MM)
Excavation & Off-site Disposal	15 ($ 562MM)	15 ($1,000MM)	15 ($823MM)	16 ($10.5MM)
Excavation & On-site Disposal	NE	NE	NE	19 (11.4MM)

NE—not evaluated (screened out)

9.5.3.5 Site Q – Ponds

This site is approximately 14 acres in size but the two ponds located on the site are the area of concern (Figure 3-2). The risk assessment for the site identified a potential risk to persons who fish and consume the fish taken from these ponds. The evaluation of this site did not identify any other risks so potential remedial actions are developed to address fishing in the ponds only. Several potential alternatives have been developed to address potential risks associated with these ponds. These alternatives are described below.

Alternative 1: No Action: As required by the NCP

The No Action alternative would assume that no further investigation, monitoring, or remedial actions would be completed at the site.

Alternative 2: Institutional Controls

This alternative would include installing a high fence around the ponds to impede ready access to the ponds for fishing. The fence around the ponds would be approximately 4,000 linear feet and would enclose both ponds. In addition, warning signs would be posted on the fence to discourage fishing and consumption of fish from the ponds. Long-term maintenance of the fences and warning signs would also be included in this alternative. Due to the recurrent flooding of these ponds it is assumed that repair and maintenance of the fence would continue indefinitely. Annual operation and maintenance costs could approach $5,000.

Alternative 3: Constructed Wetlands

Figure 9-5 shows a conceptual drawing of a seasonal wetland at the Q Ponds. The conceptual design shows that the wetland would be created by constructing a short embankment around the perimeter of the area. The embankment would provide a uniform top elevation of 407.25 feet, except at spillway locations where the top of embankment elevation is lowered to 406.25 feet. Water for the wetland would be provided by flood flows of the Mississippi River and could be supplemented by pumping from the river or from a well. Flood flows would be discharged through the spillways, which would be protected against erosion by turf reinforcement mats that would be placed along the length of the spillways.

Cuts and fills would be required within the wetland to create a moist soil environment needed to establish wetland habitat. Iterations were made to establish a bottom of wetland elevation that nearly balanced cuts and fills within the proposed wetland. Our analysis showed that a bottom elevation of 403.25 feet came closest to matching cuts and fills. If the spillways were constructed at elevation 406.25, the wetland could contain an average water depth of two feet and would allow for one foot of freeboard.

The concept for this alternative is that the wetland would be inundated each spring in order to saturate the soils and, if desired, to provide a resting place for migratory birds. The water within the wetland would be allowed to recede during the late spring and summer, during which time the wetland plants would grow. If desired, the wetland could be inundated again in the fall for the purpose of attracting migratory birds.

For the purpose of the conceptual design and preparing a preliminary cost estimate, we have included an HDPE liner beneath the wetland to isolate the wetland from the underlying groundwater. The conceptual design also includes the following:

- A 6-inch thick leveling course beneath the HDPE liner
- An 18-inch thick layer of soil on top of the liner
- A 6-inch thick layer of topsoil on top of the soil

- A water control structure to regulate water levels within the wetland and allow the wetland to be drained
- Turf reinforcement mats over the spillways.

The preliminary estimated cost to construct the wetlands is listed in Table 9-29. The estimated cost for this alternative is approximately $2.7 million. Not included in this cost are operation and maintenance costs which we estimate could approach $25,000 annually.

The groundwater surface may seasonally rise above the elevation of the liner. When this condition exists, it may be necessary to add water to the pond to prevent uplift of the liner.

Alternative 4: Pond Lining

This alternative would involve grading within the two ponds to establish a more uniform bottom elevation, placing a 6-inch thick bedding layer followed by a synthetic liner. The bottom of the larger pond would be graded to approximately elevation 398 feet, and the bottom of the smaller pond would be graded to approximately elevation 397.5 feet. The conceptual design includes a 2-foot thick layer of imported soil on top of the liner. This upper layer would be placed to support vegetation. Figure 9-6 shows a conceptual plan for this alternative. Construction of this alternative would isolate the ponds from the underlying groundwater. If desired, water could be supplied to the ponds seasonally to create the wetland habitat. We note that the pond liners would be subjected to uplift forces during periods of high groundwater levels. These forces could be balanced by pumping water into the ponds.

The preliminary cost estimate for this alternative, as detailed in Table 9-29, is approximately $0.9 million. Annual operation and maintenance costs could approach $15,000.

Alternative 5: Pond Filling

The current owner of this property is utilizing it for construction debris management and this alternative assumes the owner will use the ponds to place concrete debris, eventually filling them. There would be no cost associated with this alternative if the ponds are filled with construction debris. This alternative would involve filling the Q Ponds area to approximately the elevation of the adjacent land. Another option for this alternative would be to bring in soil from off-site to fill in the ponds. Figure 9-7 shows a conceptual grading plan assuming soil from off-site is used to fill in the ponds. The conceptual plan would raise grades to approximately

elevation 412 in the center of the Q Ponds area. Ground surface elevations would slope downward in all directions from the high to the low elevation of approximately 408 along the perimeter. Our preliminary estimates show that cut and fill volumes of 24,000 and 490,000 would be needed to achieve the final grades shown on Figure 9-7. The preliminary cost estimate for this alternative, as detailed in Table 9-29, is approximately $7.0 million. Annual operation and maintenance cost could approach $5,000.

Summary of the Detailed Evaluation of Alternatives for Site Q Ponds

Presented in Tables 9-14 through 9-18 is the detailed evaluation of each alternative with regard to the seven criteria described in Section 9.5.2. In addition, a comparative analysis is also presented in Tables 9-14 through 9-18, which ranks each alternative against the others for each criteria with the low score representing the best alternative for achieving the RAOs.

Summary of the Comparative Analysis

A summary of the comparative analysis and total ranking for each criteria for the alternatives is presented below:

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
	No Action	Institutional Controls	Constructed Wetlands	Pond Lining	Pond Filling
Overall Protection of Public Health and the Environment	5	4	1	3	3
Compliance with ARARs	5	3	1	2	4
Short-Term Effectiveness	1	2	3	5	4
Implementability	1	2	5	4	3
Long-Term Effectiveness and Permanence	5	3	2	4	1
Reduction of Toxicity	5	4	2	3	1
Cost	1 ($0)	3 ($0.19MM)	5 ($2.9 MM)	4 ($ MM)	2 ($0 MM)
Cumulative Score	23	21	19	25	**18**

For the Q Ponds site, all of the alternatives except Alternative 1 would meet the RAOs and protect human health and the environment. Institutional controls could be implemented to meet the corrective action objectives and project human health and the environment and is the most cost effective solution to meet the RAOs. The estimated 30-year present worth cost estimate for Alternative 2 is $189,000. Fencing the site and posting warning signs would significantly reduce the incidence of fish consumption. Flood events would likely impact the fence and long-term repair and maintenance would be required.

9.5.4 Description and Detailed Analysis of Groundwater Alternatives

As described in Section 9.1, the RAOs for the SA2 Sites groundwater were formulated based on environmental concerns defined in the HHRA and the BERA. One of the key factors in the outcome of the HHRA is that the use of groundwater in the vicinity of the SA2 Site as a drinking water source is prohibited. As a result, the HHRA evaluated potential incidental exposures to groundwater (i.e., non-drinking water scenarios) including contact by a construction/utility worker performing excavation in the area or volatilization through the soil column resulting in exposure to chemicals of concern in indoor or outdoor air.

With respect to the groundwater at the SA2 Sites, the key findings of the risk assessments were as follows:

- No risks to human health from exposure to groundwater were identified in the HHRA
- The only ecological risk identified was to the surface water in the area west of SA2 Sites, Site R, where groundwater discharges to the Mississippi River.

This section presents the alternatives developed to address impacted groundwater at the SA2 Sites. As with the site soils and source materials, the analysis of the alternatives has been presented in the context of specific evaluation criteria developed to address CERCLA requirements and technical and policy considerations proven to be important for selecting remedial alternatives.

The purpose of this evaluation is to identify and screen remedial alternatives that are potentially suitable for ensuring adequate protection of human (public) health and the environment considering the specific groundwater conditions and risks at SA2.

Alternatives developed for evaluation are presented in the following table:

Alternative	Description
Groundwater Alternative 1	No Action
Groundwater Alternative 2	Institutional Controls Monitoring – Groundwater Quality Monitoring – Bioaccumulation Monitoring
Groundwater Alternative 3	Physical Barrier at Site R Groundwater Extraction Institutional Controls Monitoring – Groundwater Quality Monitoring – Bioaccumulation Monitoring – Groundwater Level Monitoring
Groundwater Alternative 4	Physical Barrier Along Entire Western Boundary of SA2 Groundwater Extraction Institutional Controls Monitoring – Groundwater Quality Monitoring – Bioaccumulation Monitoring – Groundwater Level Monitoring
Groundwater Alternative 5	Hydraulic Containment and Groundwater Extraction Along Entire Western Boundary of SA2 Groundwater Extraction Institutional Controls Monitoring – Groundwater Quality Monitoring – Bioaccumulation Monitoring – Groundwater Level Monitoring

It is noted that an interim remedy (consistent with Alternative 3 herein) is currently being constructed at the site. The interim remedy includes a 3,300 foot long U-shaped slurry wall downgradient of SA2 Site R. The interim remedy also includes three groundwater extraction wells upgradient of the slurry wall. For the purpose of this streamlined feasibility study, the evaluation of the remedial alternatives was conducted as if the interim remedy was not present at the site. Therefore, the effects of the slurry wall and extraction wells were not considered in the analysis of the No Action and Institutional Controls alternative.

9.5.4.1 Groundwater Alternative 1 - No Action

The no action alternative would assume that no additional investigation, monitoring, or remedial actions would be completed at the SA2 Sites. This alternative is required by the NCP to provide a baseline for comparison of each alternative and to evaluate the conditions at the site if no further actions to minimize risk to human health or the environment were taken.

9.5.4.2 Groundwater Alternative 2 – Institutional Controls and Monitoring

Institutional Controls

Institutional controls can include access restrictions to the area of interest, as well as regulations restricting specific activity within the area of interest. This alternative is intended to mitigate potential exposure to contaminated groundwater. The institutional controls may include, but not limited to, the following:

- Access Restrictions
- Warning Signs
- Deed Restrictions
- Use Restrictions
- Community Relations.

Access Restrictions

Access restrictions include physical restrictions in the form of fencing and a locked gate. Access restrictions already in place at Site R include fencing to control access and excavation restrictions to prevent trenching without appropriate protection of construction workers. Additional institutional controls, such as posting, could be implemented to prevent recreational fishing in the area where impacted groundwater discharges to the Mississippi River. Because there are multiple property owners in the SA2 area, the alternative as a stand alone is difficult to implement.

Warning Signs

Warning signs discourage access and unauthorized excavation activities. They can be posted on security fencing and in other areas as needed.

Deed Restrictions

Deed restrictions can be filed to prohibit the use of groundwater and the installation of groundwater wells, and to prevent unauthorized excavation activities. Because there are multiple property owners in the SA2 area, the alternative as a stand alone is difficult to implement.

Use Restrictions

One significant institutional control has already been established at the Site. The Villages of Sauget and Cahokia have issued ordinances that prohibit the use of groundwater as a potable water source. These ordinances were issued in response to historic industrial use in the region, and resulting groundwater quality impairments. Copies of the ordinances are in Appendix N.

The Village of Cahokia Ordinance No. 981, published June 21, 2000 states that "The use or attempted use of groundwater from within the corporate limits of the Village as a potable water supply by the installation or drilling of wells or by any other method is hereby prohibited."

The Village of Sauget Ordinance No. 99-5, adopted October 12, 1999 states that "The use or attempted use of groundwater from within the corporate limits of the Village as a potable water supply by the installation or drilling of wells or by any other method is hereby prohibited."

Community Relations

Community relations may include an information campaign designed to ensure public awareness about the risks associated with potential ingestion of groundwater in SA2 Sites.

Monitoring

Groundwater Alternative 2 includes a well-designed monitoring program. The monitoring program will consist of two primary components; groundwater quality monitoring and bioaccumulation monitoring.

Groundwater Quality Monitoring

Groundwater monitoring will be conducted in the area of the SA2 Sites. The exact number and location of wells in the groundwater monitoring network will be established during the remedial design. However, it is assumed that the monitoring system will include wells screened in the shallow, intermediate, and deep groundwater zones at SA2 Sites.

For the purpose of this evaluation, it is assumed that the groundwater monitoring program will be conducted for 30 years and will consist of the following principal elements:

Years	Sampling Frequency	Number of Wells Sampled	Analytical Parameters
1 through 5	Quarterly Sampling	18 Clusters (59 wells)	VOCs SVOCs Pesticides Herbicides PCB Dioxins Metals TOC TDS
6 through 30	Semi-Annual Sampling	18 Clusters (54 wells)	VOCs SVOCs Pesticides Herbicides PCB Dioxins Metals TOC TDS

For the cost estimates, it is assumed that 18 new well clusters will be installed as part of the long term monitoring network. The remaining wells in the sampling program will be wells that already exist at the site.

Bioaccumulation Monitoring

Bioaccumulation monitoring will be conducted on an annual basis. Bottom-feeder fish tissue samples will be collected in the plume discharge area downgradient of SA2 Sites O, Q North, R, and S to determine if any of the contaminants discharging to the Mississippi River are accumulating in fish tissue. Bottom feeding fish are considered the appropriate trophic level to sample and monitor for bioaccumulation in a situation where impacted groundwater discharges to surface water. Focusing on bottom feeders also reduces the complexity and difficulty of sampling and analyzing fish tissue samples from all three trophic levels (bottom feeder, forager, and predator).

Three composite bottom feeder fish samples will be collected in the plume discharge area and analyzed for SVOCs, Herbicides, Pesticides, Metals, and percent lipids. Three to five fish will be collected for each composite. One composite will be collected at the north end of the plume discharge area, one will be collected in the center of the discharge area, and one will be collected in south end of the plume discharge area. Fish stomach contents will be examined and recorded to document food sources. Observations of the general physiologic condition of the fish will be made, including qualitative comments on health, behavioral abnormalities, and the presence/absence of lesions. Length and weight measurements will be maintained for those specimens submitted for analysis.

9.5.4.3 Groundwater Alternative 3 - Physical Barrier at Site R, Institutional Controls, and Monitoring

Groundwater Alternative 3 includes the elements of Alternative 2 (institutional controls and monitoring) coupled with the installation of an engineered physical barrier (slurry wall) adjacent to Site R. The purpose of the slurry wall is to prevent discharge of contaminated water from Site R to the Mississippi River. The ecological risk assessment identified an ecological risk to the Mississippi River associated with discharge of groundwater to the river at this location. This alternative is designed to mitigate this risk.

Physical Barrier

This alternative is currently being implemented as an interim remedy at SA2 Site R in accordance with the Unilateral Administration Order (V-W-02-C-716) dated October 3, 2002. A 3,300-foot long slurry wall is currently being installed at the approximate location shown in Figure 9-8. The slurry wall is approximately 3 feet wide and is being installed to a depth of 140 feet bgs.

Three groundwater extraction wells have been installed and are being operated at a combined extraction rate of up to 1,800 gpm. The extraction rate will be decreased once the construction of the slurry wall is complete in the first quarter of 2004. Groundwater modeling indicates that the three extraction wells will be operated at a combined flow rate of 535 gpm at average Mississippi River flow. A schematic showing the typical extraction well configuration is included as Figure 9-9.

All of the extracted groundwater will be treated at the ABRTF.

Institutional Controls

The institutional controls for this alternative are as described above for Alternative 2.

Monitoring

Groundwater Quality Monitoring

The groundwater quality monitoring program for Alternative 3 will be the same as described for Alternative 2. However, as shown on Figure 9-8, four of the monitoring well clusters will be installed immediately downgradient of the barrier wall. The purpose of these wells is to facilitate monitoring the performance of the slurry wall. Groundwater quality samples will collected downgradient of the slurry wall to determine mass loading to the Mississippi River resulting from any contaminants through, past, or beneath the wall. Monitoring well clusters will be constructed on the top of the riverbank downgradient of the following locations immediately adjacent to the Mississippi River (Figure 9-8).

- North End of SA2 Site R
- Halfway Between North and Center Pumping Well
- Halfway Between South and Center Pumping Well
- South End of Site R.

The sampling frequency and the analytical parameters (including the wells downgradient of the barrier wall) will be the same as described for Groundwater Alternative 2.

Groundwater Level Monitoring

Groundwater level monitoring will be performed to ensure acceptable performance of the physical barrier installed to abate the impact of groundwater discharging to surface water.

Groundwater levels will be monitored at the physical barrier to determine if gradient control is achieved. Gradient control will be determined by comparing the water-level elevations in one pair of fully penetrating water-level piezometers installed in the northwest corner of the physical barrier and one pair installed at its southwest corner. The proposed piezometer locations are shown on Figure 9-8. One piezometer of each pair will be installed inside the barrier wall and one will be installed outside it. Pumping wells and piezometers will be located on the same

north-south line. Pumping rates will be adjusted so that the water-level elevation in the inside piezometer at each corner of the barrier wall is the same as the water-level elevation in the outside piezometer. This will ensure that groundwater discharging to the physical barrier is controlled.

Electronic water-level recorders will be installed in each piezometer and telemetry will be used to send the water level data to the pump controller. Groundwater elevations inside and outside each corner of the barrier wall will be compared by the pump controller and pumping rates will be adjusted to maintain the same groundwater elevation inside the barrier wall as measured outside the wall. Physical barrier pumping rates will not be increased to the point where water levels inside the barrier wall are lower than water levels outside the barrier wall. Operating the physical barrier in this manner effectively turns it into a large collection well that will have little or no effect on achieving short-term or long-term performance measures.

Bioaccumulation Monitoring

The bioaccumulation monitoring will be will be the same as described for Alternative 2 above.

9.5.4.4 Groundwater Alternative No. 4 – Physical Barrier Along Entire Length of Area 2, Institutional Controls, and Monitoring

Groundwater Alternative 4 includes the elements of Alternative 2 (institutional controls and monitoring) coupled with installation of a physical barrier along the entire western side of Area 2, adjacent to the Mississippi River. The purpose of the barrier is to prevent discharge of contaminated groundwater to the Mississippi River.

The ecological risk assessment (Menzie-Cura and Associates, 2001) identified a risk associated with discharge of groundwater to the Mississippi River at the location of Site R. Although the concentrations do not present an ecologic risk, this alternative also prevents the discharge of groundwater with contaminant concentrations above Illinois Class I Groundwater Standards. Groundwater exceeding these standards is present throughout the SA2 area, however risk to human health is limited because the water is not used as a drinking water source and the concentrations do not present an ecological risk.

Physical Barrier

Figure 9-10 shows the conceptual layout of the barrier wall that would be installed as part of Groundwater Alternative 4. As shown on the Figure, the wall would be approximately 12,000-feet long with 750 foot wing walls on the north and south ends. The wall would be 3 feet wide and would be installed to approximately 140 feet bgs.

Construction of a barrier wall of this length will require excavation and disposal of approximately 273,000 cubic yards of potentially contaminated materials from the trench. It is assumed that the excavated material would be temporarily stockpiled at the SA2 Site nearest to where the excavated material was generated. It is noted that significant challenges would be associated with disposal of the 273,000 cubic yards of potentially contaminated soils from the barrier wall installation and management of the material at the site closest to the trench would be required as close as possible to the trench.

As shown on Figure 9-10, 24 groundwater extraction wells would be installed upgradient of the barrier wall. The purpose of the extraction wells is to abate the discharge of groundwater to the wall. A schematic showing the typical extraction well configuration is included as Figure 9-9.

The estimated combined flow rate from the extraction well system is 3,000 gpm. This estimate is based on the volume of groundwater that enters the barrier wall and does not include extraction of any groundwater in excess of the natural flow rate to the wall. The extraction well spacing and flow rates were estimated with the use of a groundwater flow model. Appendix M contains a detailed outline of the analysis conducted to estimate these design parameters.

All of the extracted groundwater will be treated at the ABRTF.

Institutional Controls

The institutional controls for this alternative are as described above for Alternative 2.

Monitoring

Groundwater Quality Monitoring

The groundwater quality monitoring program for Alternative 4 will be the same as described for Alternative 2. However, as shown on Figure 9-10, eighteen monitoring well clusters will be installed on the downgradient side of the barrier wall. The purpose of these wells is to facilitate

monitoring the performance of the barrier wall. The monitoring well spacing (667 feet) is consistent with the well spacing used for the interim remedy currently being installed at Site R. Groundwater quality samples will collected downgradient of the slurry wall to determine mass loading to the Mississippi River resulting from any contaminants through, past, or beneath the wall.

The sampling frequency and the analytical parameters (including the wells downgradient of the barrier wall) will be the same as described for Groundwater Alternative 2.

Groundwater Level Monitoring

Groundwater level monitoring will be performed to ensure acceptable performance of the physical barrier. Groundwater levels will be monitored at the physical barrier to determine if gradient control is achieved. Gradient control will be determined by comparing the water-level elevations in six fully penetrating water-level piezometers installed inside or upgradient of the physical barrier to water levels in corresponding monitoring well clusters on the outside or downgradient side of the barrier wall. The proposed piezometer locations are shown on Figure 9-10. Pumping wells and piezometers will be located on the same north-south line. Pumping rates will be adjusted so that the water-level elevation in the piezometers inside the barrier wall is the same as the water-level elevation in the monitoring wells outside the barrier wall. This will ensure that groundwater discharging to the physical barrier is controlled.

Bioaccumulation Monitoring

The bioaccumulation monitoring will be will be the same as described for Alternative 2 above.

9.5.4.5 Groundwater Alternative No. 5 – Hydraulic Containment through Aggressive Pumping Along Entire Length of Area 2, Institutional Controls, and Monitoring

This alternative includes the elements of Alternative 2 (institutional controls and monitoring) coupled with hydraulic containment / aggressive extraction of the contaminated groundwater along the entire western side of Area 2, adjacent to the Mississippi River. The potential benefits of this alternative are twofold. First, the alternative would provide hydraulic control and prevent discharge of groundwater containing contaminants above the Illinois Class I Groundwater Standards to the Mississippi River. Secondly, this alternative would include extraction of groundwater at the maximum sustainable rates. This aggressive extraction would increase the

groundwater flow rate through the contaminated source areas in Area 2 and would therefore result in a shorter cleanup time.

The conceptual layout of the extraction wells and piping system for this alternative is shown in Figure 9-11. The system would include installation and operation of 24 groundwater extraction wells on the west side of the SA2 Sites adjacent to the Mississippi River. The estimated maximum sustainable flow rate from each well is 1,100 gpm. The combined extraction rate would be 26,400 gpm. The extraction well spacing and flow rates were estimated with the use of a groundwater flow model. Appendix M contains a detailed outline of the analysis conducted to estimate these preliminary design parameters.

The groundwater extraction rate of 26,400 gpm or approximately 38 million gallons per day (MGD) would exceed the current capacity of the ABRTF. This facility was designed to treat 27 MGD. Information from the facility indicates that they are currently treating approximately 15 MGD. This would indicate that the facility has the excess capacity to treat 12 MGD. Therefore, Groundwater Alternative 4 would require construction of a treatment facility to manage an additional 26 MGD (38 MGD extracted groundwater minus the 12 MGD that could be treated at the ABRTF).

With respect to the groundwater treatment costs, the estimates for Groundwater Alternatives 3 and 4 are based on the current rate of $5.00/1000 gallons treated at the ABRTF. Since the treatment facility has established this rate, it is assumed that this estimate is sufficient to cover routine operation and maintenance expenditures as well as long term recovery of capital costs to design and build the facility.

For Alternative 5, the same $5.00/1,000 gallons treated is used in the cost estimate. Although the aggressive extraction rate will require construction of an additional treatment facility with capacity to treat 26 MGD, the capital costs to construct such facility are not included in the estimate. Rather, it is assumed that it would be economically feasible for the treatment plant operator to design and construct an additional facility and recoup the capital investment in a reasonable timeframe as groundwater is treated at rate of $5.00/1,000 gallons. The fundamental element in this approach would be a contractual long-term commitment of the SA2 Sites stakeholders to deliver a substantial, pre-determined influent rate to the treatment facility. Under this scenario, it is plausible that the treatment plant owner would be willing to make the capital

investment with the promise of recovering the investment as groundwater is treated over a long period of time.

Institutional Controls

The institutional controls for this alternative are as described above for Alternative 2.

Monitoring

Groundwater Quality Monitoring

The groundwater quality monitoring program for Alternative 5 will be the same as described for Alternative 2. However, as shown on Figure 9-11, eighteen monitoring well clusters will be installed along the Mississippi River, downgradient of the line of 24 extraction wells. The purpose of these wells is to facilitate monitoring the performance of the groundwater extraction system.

The sampling frequency and the analytical parameters (including the wells downgradient of the barrier wall) will be the same as described for Groundwater Alternative 2.

Groundwater Level Monitoring

Groundwater level monitoring will be performed to ensure acceptable performance of the hydraulic containment / aggressive extraction system. For this alternative, the objective is to remove groundwater at the maximum sustainable flow rate, rather than to optimize flow rates necessary to achieve hydraulic control and/or remove water entering a barrier (as in Alternatives 3 and 4). Therefore, the groundwater levels in the aquifer at locations away from the extraction wells are not as critical to the success of this alternative. Rather, the drawdown in individual extraction wells will be monitored and adjusted to achieve maximum extraction rates. Therefore, the conceptual layout of this alternative does not include additional water level piezometers in the vicinity of the extraction system.

Demonstration and monitoring of hydraulic control at the western edge of SA2 will be based on routine water level measurements in the monitoring well clusters that are part of the overall groundwater quality monitoring network.

Bioaccumulation Monitoring

The bioaccumulation monitoring will be will be the same as described for Alternative 2 above.

9.5.5 Summary of the Detailed Evaluation

Tables 9-19 through 9-23 present the detailed evaluation of each the five groundwater alternatives with regard to the seven criteria described in Section 9.5.2.

Tables 9-24 through 9-29 present a cost estimate for each alternative including Capital Cost, Annual Operation and Maintenance Cost (if any), and a 30-year Present Worth Cost.

9.5.6 Summary of the Comparative Analysis

In the following sections, Groundwater Alternatives 1 through 5 are compared to one another to identify the relative advantages and disadvantages of each. A forced ranking system was used to identify the alternatives that best achieves the requirements of the seven evaluation criteria used to evaluate remedial alternatives. This analysis ranks each alternative against the others, with the low score representing the best alternative for achieving the specific criterion. Each component of the alternatives is given a ranking of 1 through 5 for each criterion representing the best alternative to address the criteria (ranking of 1) to the least effective (ranking of 5). The scoring is based on engineering judgment based on review of the site conditions and professional judgment. The summary scores are presented at the end of this section.

9.5.6.1 Overall Protection of Public Health and the Environment

Alternative 1 does not provide for additional protection of human health or the environment.

Alternative 2 is protective of human health. The institutional controls associated with the ordinances against use of groundwater as a drinking water source are protective and result in no risk to human health associated with the groundwater at the site. However, Alternative 2 does not address the ecological risk associated with discharge of groundwater to the Mississippi River at the location of Site R.

Alternatives 3, 4, and 5 are protective of human health and the environment. All three alternatives include institutional controls to protect human health and also include components that prevent discharge of groundwater at Site R and therefore mitigate the ecological risk to the Mississippi River at this location. However, since the only ecological risks were related to discharge downgradient of Site R, Alternative 3 provides equal risk protection at a lower cost.

9.5.6.2 Short-Term Effectiveness

Groundwater alternatives 1 and 2 do not include short-term risks to remedial workers as the alternatives would be implemented. However, both alternatives would result in a short-term risk to the environment since they do not include elements to address the risk associated with groundwater discharge to the Mississippi River. Both alternatives rely on natural processes to reduce the adverse ecological impacts resulting from groundwater discharge to surface water. Natural processes will not reduce adverse impacts on the Mississippi River in the short term.

Groundwater Alternative 4 could be implemented in a reasonable time frame. Short term risks to remedial workers during installation of a physical barrier and extraction wells along the western side of SA2 Site could be managed. Alternative 5 is considered the poorest option with respect to short-term effectiveness. This alternative includes extraction and treatment of an extremely large volume of contaminated groundwater on a daily basis. Treatment of this water would require significant efforts to manage the short-term risks to remedial workers conducting the on site operation and maintenance activities and to the treatment plant operators.

Groundwater Alternative 3 is clearly the best alternative with respect to short-term effectiveness. The most important factor leading to this conclusion is that Groundwater Alternative 3 is already being installed as an approved interim remedy at the site. Construction of the 3,300-foot long slurry wall is scheduled to be completed the first quarter of 2004. The extraction wells associated with this alternative are already installed and are being operated to maintain hydraulic control of the groundwater downgradient of Site R. Construction of the barrier wall at Site R will mitigate the ecological risk associated with discharge of groundwater to the river.

9.5.6.3 Implementability

Groundwater Alternative 1 (No Action) is the easiest to implement as nothing more is required. However, groundwater Alternative 3 is currently being implemented and all applicable permits and permissions are in place. As a result it is the second easiest to implement. The extraction wells have been installed and treatment of the extracted groundwater at the ABRTF has commenced. All of the principal technical challenges and planning decisions have been finalized for this alternative.

Although Groundwater Alternative 1 could be implemented relatively easily from a technical standpoint, it is unlikely that this alternative would be acceptable to the agencies involved or to the public.

Although Groundwater Alternatives 4 and 5 could be implemented from a technical standpoint, each alternative would include significant challenges that would require careful consideration and upfront planning. The primary challenge with Alternative 4 would be the disposal of the spoils or cuttings during installation of the physical barrier. The barrier would be over 12,000-feet long and would result in excavation of approximately 273,000 cubic yards of potentially contaminated materials. Groundwater Alternative 5 would include construction of a wastewater treatment plant and would require significant planning to manage the treatment of approximately 38 million gallons of groundwater on a daily basis.

9.5.6.4 Compliance with ARARs and Other Criteria, Advisories, and Guidance

Based on the discussion in Section 9.4, Illinois Class I Groundwater Standards and federal MCLs are appropriate ARARs for SA2 groundwater. 35 IAC 620.250 provides for the establishment of a groundwater management zone, wherein alternate water quality standards are allowed in accordance with 35 IAC 620.450. Each of the five alternatives for the SA2 Site groundwater is compliant with ARARs.

9.5.6.5 Long-Term Effectiveness and Permanence

Groundwater Alternatives 1 and 2 provide no long term effectiveness or permanence.

Alternatives 3, 4, and 5 include extraction and treatment of groundwater. Each of these alternatives provides a long term, effective solution for managing the risks associated with the SA2 Site Groundwater. The treatment of groundwater will provide a permanent removal of a relatively small mass of contaminants. Groundwater Alternatives 3 and 4 provide an added benefit of the installation of a permanent barrier wall that will impede discharge of groundwater to the Mississippi River.

The analysis presented in Appendix M includes a relative comparison of the remediation timeframes for each of the five groundwater alternatives. Planning level source lifetime calculations predict that groundwater remediation timeframes will be up to 351 years. Groundwater Alternatives 1 through 4 do not decrease the remediation timeframe since the groundwater flow rates through contaminated areas would be the same as the rate under natural

conditions. Intensive groundwater pumping associated with Alternative 5 generally shortens the remediation timeframe by approximately 60 percent. Site R is expected to have the longest remediation timeframe, with 351 years predicted for Alternatives 1 through 4 and 140 years for Alternative 5.

9.5.6.6 Reduction of Toxicity, Mobility, or Volume through Treatment

Groundwater Alternatives 1 and 2 rely on natural processes to reduce the toxicity, mobility, and volume of contaminants. Alternatives 3 and 4 reduce the mobility of groundwater contaminants by physical control and removal of affected groundwater before it discharges to the Mississippi River.

Although the groundwater along the western side of the SA2 sites does contain contaminants at concentrations above Illinois Class I Groundwater Standards, greater than 99 percent of the total estimated contaminant mass at SA2 is associated with Site R. Therefore, the slurry wall and groundwater extraction system included in Alternative 3 (currently being installed as an interim remedy at the site) are expected to capture over 99 percent of the overall contaminant mass being discharged from SA2. Appendix M presents a technical memorandum regarding the estimated pumping rates and remediation timeframes developed for the groundwater evaluation in the streamlined feasibility study. As part of the analysis, the technical memorandum includes an evaluation of the source concentrations and estimated source mass at SA2. A summary of the estimated contaminant mass at each of the SA2 Sites (Sites O, P, Q, R, and S) is presented in Table 4 of the memorandum. As shown on the table, greater than 99 percent of the total estimated contaminant mass at SA2 is associated with Site R. Therefore, the slurry wall and groundwater extraction system (Groundwater Alternative 3) currently being installed as an interim remedy at the site are expected to capture over 99 percent of the overall contaminant mass being discharged from SA2.

Alternatives 4 and 5 include elements that significantly reduce or prevent discharge of groundwater to the river along the entire length of the SA2 Site, but do not provide significant additional mass removal.

With Alternative 5, groundwater will be extracted and treated at a rate of 26,400 gpm. This flow rate is approximately 8.7 times the natural groundwater discharge rate to the Mississippi River. Extraction and treatment of groundwater at this aggressive rate will result in the treatment of

approximately 13.9 billion gallons of groundwater on an annual basis and an overall decrease in the cleanup time from 350 to 140. Treatment of this water will result in an overall decrease in the toxicity, mobility, or volume of contaminants discharging to the Mississippi River.

In comparison to Groundwater Alternative 3, Groundwater Alternatives 4 and 5 would not significantly decrease the overall contaminant mass being discharged to the river.

9.5.6.7 Cost

No costs are associated with Alternative 1. The following table presents a summary of the estimated costs associated with Alternatives 2, 3, 4, and 5.

	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Capitol Costs				
Institutional Controls	$0	$0	$0	$0
Monitoring Well/Piezometer Installation	$326,033	$334,505	$337,541	$326,033
Barrier Wall Installation	$0	$7,383,000	$28,313,000	$0
Extraction Well Installation	$0	$385,473	$2,519,911	2,750,087
Groundwater Treatment at POTW	$0	$0	$0	$0
Subtotal, Capitol Costs	$326,033	$8,102,978	$31,170,452	$3,076,120
O&M Costs (PV)				
Institutional Controls	$248,181	$248,181	$248,181	$248,181
Monitoring	$5,251,364	$5,251,364	$5,251,364	$5,251,364
Extraction System O&M	$0	$323,821	$1,799,212	$7,459,869
Groundwater Treatment at POTW	$0	$17,446,864	$97,832,881	$860,929,350
Subtotal O&M Costs, Present Value	$5,499,545	$23,270,230	$105,131,637	$873,888,764
Total Capitol Costs plus O&M Costs, Present Value	$5,825,578	$31,373,208	$136,302,089	$873,964,884

Based on the information presented above, a summary of the comparative analysis and total ranking for each component of the five alternatives is presented in the following table.

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
	No Action	Institutional Controls	Physical Barrier at Site R	Physical Barrier Along Area 2	Hydraulic Containment Along Area 2
Overall Protection of Public Health and the Environment	5	4	3	1	2
Compliance with ARARs	5	4	3	2	1
Short-Term Effectiveness	2	3	1	4	5
Implementability	1	3	2	4	5
Long-Term Effectiveness and Permanence	5	4	1	2	3
Reduction of Toxicity	5	4	2	3	1
Cost	1 ($0)	2 ($5.8 MM)	3 ($31.4 MM)	4 ($136.3 MM)	5 ($877.0 MM)
Cumulative Score	24	24	**15**	20	22

Comparative Analysis Summary

A summary of the comparative analysis and the associated cost is provided below.

Comparative Analysis Results – Source Control Remedies

Sites O and O North	RCRA/TSCA Cap	$ 7.8MM
Site Q North	RCRA/TSCA Cap	12.0MM
Site R	RCRA/TSCA Cap	6.7MM
Site S	RCRA/TSCA Cap	0.36MM
	Subtotal	**$26.9MM**

Comparative Analysis Results – Groundwater Control Remedy

Groundwater	Physical Barrier and Groundwater Extraction at Site R	31.4MM
	Total	**$58.3MM**

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